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Contents.

	PAGE
The British Cast Iron and Steel Castings Research Association	61
Correspondence	62
Discussion on Mr. E. J. Fox and Mr. P. H. Wilson's Paper on "The Principles of Centrifugal Casting as Applied to the Manufacture of "Spun" Iron Pipes"	63
A Note on Wood Joints	64
Casting Design	65
Oil Sand Cores and Production	69
Catalogues Received	73
Foundry Economics	74
Aluminium Pistons Growing in Favour	75
The Institute of British Foundrymen	76
New Companies	78
Trade Talk	80
Personal	80
Obituary	80
Iron and Steel Markets	82

Forthcoming Events.

JANUARY 29.

Institution of Welding Engineers:—Ordinary meeting at Leeds. "The Arc Welding of Seams in Steel Plates," Paper by J. T. Carr, A.Sc.

Institute of British Foundrymen (Sheffield Branch):—Annual dinner.

JANUARY 30.

Institute of Metals (North-East Coast Local Section):—Joint meeting with the Institute of British Foundrymen at Newcastle-on-Tyne.

FEBRUARY 15-26.

British Industries Fair:—London and Birmingham.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The British Cast Iron and Steel Castings Research Association?

It is definitely certain that sooner or later a British steel castings research association will be formed. It is a natural development consequent upon the requirements of modern progress, and the interesting factors at the moment worthy of consideration are: (1) Who is to sponsor the proposition? and (2) the nature of the organisation. Of the urgency of the matter there is no question, as we are aware that two privately-owned research organisations are covering the same ground.

For the successful prosecution of any co-operative research organisation, a reasonably complete *exposé* of existing knowledge is a fundamental requirement. This obviously for steel castings includes moulding sands, raw materials, and *a number of other subjects common to cast iron*. The files, containing existing data, would be largely duplicates of those now built up by the British Cast Iron Research Association. A steel casting research association would demand an organisation for the collection and dissemination of specialised information practically parallel with the B.C.I.R.A.'s existing system. From a research-output point of view, the first few years would be barren, because of the time spent in propaganda and organisation-building.

Viewed from no matter what angle, the steel founders' research association, when it comes into being, as come it must, will be best served by attaching itself to the B.C.I.R.A.

In America no national co-operative research exists for steel castings, but there is a steel founders' research group, directed by Major Bull.

It may be thought desirable for a similar private organisation to come into being on this side. Its advantages are that it has increased flexibility, whilst to be counted as disadvantages are the facts that (1) it cannot have the beneficial close association with Government Departments; (2) its structure is liable to be undermined by changes in its direction regarded from the widest standpoint; (3) it would be less able to claim any Government grants which have been, are being, or may be made for the prosecution of industrial research; and (4) the likelihood of its absorption by any national organisation formed.

This fourth item has actually come about in the cast-iron industry, for the Falkirk Technical Institute is being absorbed into the British Cast Iron Research Association. We are giving details of this change in the near future. It is not because the Institute has not done good work in the past; on the contrary, some excellent reports have been made, and Mr. Cowan is to be congratulated upon his work. It is merely a natural process designed to widen the sphere of activities to the largest dimensions; to tap as many sources of information as possible, and more economically to secure results.

There is just one factor remaining to be discussed—that is, how would the ironfoundry industry regard the expansion of their research organisation to take in steel castings. We honestly believe the former have everything to gain, because, as an industry, steel castings is very much better *documenté*, possibly because of its close association with wrought steel. A larger percentage of the steel industry is metallurgically organised than iron. It has habitually been applying the results of research for two or more decades. The solution of many of the steel founders' problems would throw light upon, if not definitely solve, analogous problems in the cast iron industry. Finally, though smaller, it is, generally speaking, a more enlightened industry from the metallurgical point of view.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Foundry Costing.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We have been greatly interested from time to time perusing your numerous articles which have dealt with the subject of "Foundry Costing," and the recent remarks in your issue of January 16 have prompted us to communicate with you regarding the subject. Most of these articles have pointed out the desirability of installing an efficient costing system in all foundries, and have made mention of the amount of research work which is being employed in order to find, if possible, an ideal. Everyone with any experience of foundry work knows of, and deplores, the lack of some simple and workable system which would immediately give a reliable price for a casting, with the elimination of any guesswork, which is the trouble with most of the known present-day systems.

Personally, we have had a wide and varied experience in foundry costing and practical work, and have met with all the difficulties therein involved, many of which are caused by the unreliability of so-called systems. In fact, so fluctuating were some of the results obtained by these methods that, to quote an example, a casting made one week would apparently cost 18s. per cwt., and the same article next week 21s. per cwt., thus making the computation of a standardised price list an extremely risky proposition. This state of affairs is felt most acutely in foundries engaged in general work, and very often returns show that it is impossible to make a certain article pay for itself, yet in order to keep in the market in competition with firms who are costing with a false system, the article has to be sold continually at a loss, hence the immediate need for a standardised system.

After many years of experimenting and tabulation of figures, we have evolved a system which has been worked by ourselves and found practicable for a number of years. Providing it was possible to install and standardise our system throughout the country, we candidly believe it would put foundry costing on a sound basis and also supply an immediate, economic, reliable and competitive price for any casting and would be invaluable for quoting purposes and eliminate all guesswork. Below we give you a few examples taken from our figures:—

From 28 to 56 lbs., 26s. 5d. per cwt., and from 3½ to 4½ cwt., 14s. 8d. per cwt. (These are instances of hand-moulded general work, but if castings of similar weight were plate-moulded the price per cwt. would be 16s. 4d. and 10s. 7d. respectively.)

Loam Moulding.—10 cwt. to 20 cwt., 20s. 3d. per cwt.

Open Sand Moulding.—5 cwt. to 10 cwt., 7s. 5½d. per cwt.

(The above prices are obtainable from the system at a glance in each instance.)

The system could be installed in any size of foundry, is simplicity in its working, very compact, and not only gives the cost price of castings per cwt., but shows the weight necessary to be turned out weekly, the maximum amount of standing and working charges allowable, and the number of moulding hours required for each job.—Yours, etc.,

F. H. AND L. W. B.

The Birth of the Electric Furnace Industry.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Your editorial note following a letter from Messrs. Edgar Allen & Company, Limited, in the present issue of the Journal calls for some information which we can supply to help towards a correct record of the early days of the above industry.

The electric furnace you mention, and which we operated at our Sheffield works, was first put into commission in either September or October, 1910, the exact date could be given, but would entail a long search in view of the records having been transferred, many years ago, to our Dunston steelworks, and there packed away with a host of other documents.

That furnace was, therefore, the second arc furnace to be put into commercial use in this country. It was, however, the first to be completely designed and built in this country, we having designed it for the Electro-Metals Company, incorporating the electro-metals electrical system.

Other numbered points you ask for are as follows:—

(1) The largest electric melting furnace built in this country was a 20-ton stationary one, which we built at our works in 1917 as the primary of a duplexing system for the manufacture of synthetic pig-iron. That plant was run during the dearth of pig-iron during the war, but was not commercially useful thereafter.

The largest electric steel melting furnaces in this country are the Stobie furnaces built by us for Messrs. Armstrong Whitworth & Company, and for our own steelworks. These, though nominally 12-ton furnaces, made heats up to 15 tons, the record being 15 tons 15 cwts. at Armstrong Whitworth's Works.

(2) Although we do not know if we made the first cast of high-speed steel in an electric furnace,* we probably were the first to make it in 10- to 12-ton heats, which we did regularly in 1916.

(4) The first cast of stainless steel was most probably made by Messrs. T. Firth & Sons, but we made heats in a 5-ton Stobie furnace in 1915.

(5) The first Stassano furnaces in this country were installed by our then near neighbours, the Electro-Flex Steel Company, at Dunston, in 1912.

(6) The first large electric steel melting furnace in this country was a nominal 12-ton (actual 15 ton) Stobie furnace designed by us for our own steelworks in 1913, which was put into commission in 1915. A 15-ton Heroult furnace was decided upon in the early days for the Skinningrove Iron Company, but we believe the scheme was abandoned later for want of electric current.

The first British designed and built electric steel furnace, other than the one we mention in our third paragraph, was a 5-ton Stobie furnace we installed in our works in 1913. This was designed at the end of 1911.

We believe, though we have no proof whatever, that we were the first electric steel manufacturers to use anthracite in connection with slag operations; the previously used carbonaceous material, at any rate on the Continent, was petrol coke.

(7) We introduced the now usual process of carbonising steel in the electric furnace by the addition of anthracite to the bath immediately after slagging, and before any fresh slagging materials or any deoxidisers were added.

The first successful and, we claim, the present best economisers for arresting the loss of current, electrodes, and metallurgical control which resulted in the old days from the unsatisfactory glands around the electrodes, where these pass through the roof of a furnace, was experimentally used by us in 1915 and commercially in 1916.

The first use of graphite electrodes for electric steel furnaces in this country was at our works in 1914. Yours, etc.,

THE STOBIE STEEL COMPANY,
M. R. Compston.

Dunston-on-Tyne, January 22, 1926.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With further reference to our letter of January 15, reprinted in your issue of January 21, you are quite correct in stating that the Heroult furnace at our works was engaged upon the manufacture of tool steel for some time after its installation. Messrs. Lake & Elliott's furnace was, therefore, the first in the country to be used for the commercial manufacture of steel castings. You will understand that ours was, nevertheless, the first electric furnace used commercially for producing steel, and it was this point that our original letter was intended to make clear, as Mr. Primrose, in his remarks, attributed the first commercial production of steel by the electric furnace process to Messrs. Lake & Elliott.—Yours, etc.,

EDGAR ALLEN & COMPANY, LIMITED,
R. G. WOODWARD,
Director.

Imperial Steel Works, Sheffield,
January 25, 1926.

* High-speed turnings were made into ingot form in 1911, at Warren Street.—Editor.

Discussion on Mr. E. J. Fox and Mr. P. H. Wilson's Paper on "The Principles of Centrifugal Casting as Applied to the Manufacture of 'Spun' Iron Pipes."

At the close of the Paper, which was printed in our issues of January 14 and January 21, the following discussion took place:—

Synchronisation of Movements.

MR. HERBERT raised the question of the speed of moving the mould and the tipping of the discharge synchronising with each other. These two movements were worked by hydraulic pressure, and, so far as he understood, they were not geared. Therefore, one had to depend on the opening of the hydraulic valve for synchronisation, and he did not think that was practicable.

MR. WILSON replied to the effect that the pumps which supplied water-pressure for operating these machines were of the centrifugal type, and, in addition, there was fixed on the main a special type of air receiver with a capacity sufficiently large to make up the slight variation in pressure caused by the various machines working together. In practice, they found that it was possible to work within limits sufficiently accurate for the production of a pipe uniform in thickness.

MR. HERBERT added that it would be interesting to learn whether they could spin the mould too fast.

MR. WILSON pointed out that the speed of rotation of the mould was a very important factor, and that the correct speed had been ascertained for each size of pipe cast, this speed having been arrived at by numerous tests carried out on pipes cast at different speeds. It is possible to spin a mould too fast, as, if the speed increased to any extent beyond the optimum speed, it would have an adverse effect on the quality of the pipe.

Tests for C.I. Pipes.

MR. HERBERT said that 20 tons per sq. in. tensile strength had been mentioned for spun pipes, and there were also some figures relating to the actual bursting pressures. In the spun pipes he believed it worked out at about 14½ tons per sq. in., and, on the average, a little over 8 tons per sq. in. for sand-cast pipes. He added that the only thing he could say was that 8 tons per sq. in. on the metal in the ordinary cast-iron pipes corresponded with what they would get in an ordinary test, but understood that 9½ tons was asked for in the British standard specification, which he considered too much.

In answer to the first part of Mr. Herbert's question, MR. WILSON referred to the part of the Paper in which it was expressed that the tensile strength calculated from the bursting pressures was low, both for sand-cast and spun pipes, and this was due to combined stresses set up in the pipes, due to the high end-pressure necessary to make a satisfactory joint to withstand such a high pressure. The results given later, on separate test bursts, proved that the metal in both classes of pipe was considerably stronger than that calculated from the bursting pressures.

MR. FOX pointed out that he did not agree with Mr. Herbert that 9½ tons per sq. in. tensile strength specified by the British Standard Association was too high for ordinary cast iron; at Stanton Works they had no difficulty in obtaining a figure something higher than this in their ordinary sand-cast metal.

Water Hammer.

MR. GARDINER asked if any enlightenment could be given with regard to the manner in which these pipes stood up to shock, say, through water hammer. Were they quite as good as sand-cast pipes?

MR. WILSON pointed out that they had paid particular attention in their investigations in testing pipes to ascertain their resistance to shock. For the purpose of their investigations they had constructed a special type of machine for drop testing. For the purpose of this test the pipes were supported on a cast-iron saddle, and the weight dropped at various heights, whilst the pipe was under internal water pressure. The results obtained from this test proved that the spun pipes, although 25 per cent. lighter, gave better results than the thicker sand-cast pipes.

Migration of Elements.

In reply to Mr. Campion on the question of the migration of the manganese, this element tends to migrate to the *inside* of the pipe, when present as manganese sulphide. In the Stanton spun pipe, the manganese is present to the extent of 0.35 per cent. The sulphur present is sufficient to convert the whole of the manganese into manganese sulphide, so that, in the case of Stanton spun iron, there would be no manganese present other than the sulphide.

In the case of an iron with a higher manganese content, the excess manganese over that required to combine with the sulphur would be present as manganese carbide.

MR. CAMPION suggested that this manganese carbide would migrate along with the iron carbide.

MR. WILSON stated that in their opinion this manganese carbide would be spread evenly through the mass. The authors have no definite data to support this statement, except the fact that the manganese carbide would be in solution along with the iron carbide, and solutions do not migrate. The carbon as graphite migrates, but not the combined carbon.

Carl Pardhun, in "Stahl und Eisen," August 28, "Principles of Centrifugal Casting," expressed a similar opinion to the above. He said:—

"So long as manganese is combined with sulphur it migrates towards the inner zone.

"If the amount of manganese combined with sulphur is deducted from the total manganese it is found that the residual manganese is practically equal in extent in all zones."

The figures given in the Paper refer to the total manganese.

Growth of "Spun" Iron.

In regard to the question of the growth of spun iron, this is a matter which at present has not been investigated. Grey cast iron, generally speaking, commenced to grow as soon as heating begins; in grey cast iron the graphite is much coarser than in the spun iron. In the latter it was distributed in a very fine form; this fine graphite distribution accounts to a large extent for the increased strength of the spun iron.

It had been noticed that this fine structure and also the strength do not suffer by annealing for a short time.

Spun iron had been found very good for piston rings, but they had no definite figures to hand as to the question of growth.

He agreed with Mr. Campion that this subject offered a distinct field for research.

Life of Steel Moulds.

With regard to the life of the steel mould, the suggestion had been made that a mould made from some special alloy might be used. They had several well-known metallurgists working on this subject in this country, and they were also carrying out experiments with different materials in the U.S.A. Several special alloy steels have been tried, and the difficulty they had found was that, if they obtained an alloy which was ideal from one point of view, it was weak from another. What was required was a material which would stand repeated outside cooling and inside heating, or the continual "breathing," as it was termed, which took place in the mould itself during the casting of a pipe.

A member asked as to the method to be adopted in cutting pipes produced by the centrifugal process, inquiring as to whether in cutting a spun pipe the wheel should be used. It was sometimes difficult, he said, to get the cutter into use owing to congestion in streets, for example. With regard to boring, he asked whether spun pipes were more difficult to drill than sand-cast pipes.

MR. WILSON said it was his experience that users of both spun and sand-cast pipes preferred using a diamond point and a flat chisel for cutting pipes underground, particularly in congested streets. Wheel cutters could be used for pipes that required cutting above ground. He also pointed out it had come to his knowledge that recently a machine using a cutting-off tool had been placed on the market. This machine was in two parts, and could be clamped round the pipe to be cut, the cutting off portion being drilled from the ground level by means of a chain and sprocket wheels.

With reference to the possibility of cracking the pipe when drilling for surface connections, he had had no experience of this trouble, but this might possibly happen in any pipe if an attempt was made to feed the drill too quickly. As far as tapping was concerned, his firm had been complimented on this point, as the thread produced was much stronger than that obtained in ordinary cast iron. Samples were on the table for the members of the audience to inspect after the meeting.

Centrifugally Casting in Sand Moulds.

Another question was put from the audience asking whether centrifugal pipes could be cast by sand moulds instead of steel moulds?

MR. WILSON replied that he had had some experience of casting centrifugally pipes in sand-rammed moulds, running the metal into the mould in a similar manner to what they were doing to-day, and that he understood experiments were now being carried out in America on these lines. The objection to this method of casting was, in the first place, the production was considerably slower than that which could be obtained from a permanent mould; secondly, the internal surface of the pipes was considerably rougher; and, thirdly, due to the slow rate of cooling, the pipes were very little stronger, if any, than those cast in the ordinary method, and that he did not consider any advantage could be claimed for this method of casting over that of the ordinary vertically cast pipes.

MR. LAWRIE pointed out that in the tests made with pipes made by the centrifugal method and pipes made in the ordinary way, it was stated by the lecturers that 'the metal was taken from the same ladle. That might be, but he would like to say that in this particular case the metal might be suitable for centrifugal casting, and not suitable for sand casting; consequently, the test would probably be against the sand-made casting. He thought that, in fairness to the old method, that should be taken into account. If the silicon was reduced down to the necessary degree to give a strong sand casting, they would get a far better test. He congratulated the Stanton Company on what they had accomplished.

MR. WILSON agreed with what Mr. Lawrie said with regard to the silicon content in the metal used for sand-cast pipes and spun pipes, but pointed out that the figures shown were taken at an early stage in their experimental work, and that the iron used in this case was suitable for sand-cast pipes. In other words, the metal was taken from a cupola which was supplying metal to the vertical pipe pits and was not specially melted for the production of spun pipes.

A question was asked if any attempt had been made at casting thin pipes by this centrifugal process, and MR. WILSON, in his reply, stated that his firm had experimented in this direction, and had been able to produce pipes 6 in. external diameter, 12 ft. long, as low as $\frac{1}{8}$ in. thick.

Patent Specifications Accepted.

The following list of patent specifications accepted have been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full specification can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

15,823. SCHAAP, A. K. Heat-treatment of grey iron castings. July 1, 1924.

23,210. FLETCHER, J. E., and YOUNG, H. J. Iron castings. October 1, 1924. (Cognate Application, 7,342/25.)

A Note on Wood Joints.

By T. McL.

Is British patternmaking practice right in not adopting the various joints of carpenters and cabinetmakers? The writer has frequently heard the subject discussed, but if a comparison be made of British and American patterns we do not appear to have much to learn as regards constructional methods generally, and certainly not about jointing. The reason why carpentry methods are common in American patternshops is that their woodworkers change almost without restriction from one occupation to another.

In a certain overseas technical journal there recently appeared an article on the importance of dovetail joints in patternmaking. As a matter of fact, the dovetail joint is not, except for a few special jobs, satisfactory in pattern construction, although it is the most useful joint for joiner work and cabinetmaking. Foundries always decide that patterns have been made by joiners when dovetails are used. The dovetail joint is strong, but not popular in patternshops.

One reason why dovetails are not suitable for patternmaking is that they are too unyielding, and another that such a joint is not, as a rule, sufficiently accurate. Further difficulties arise if a boxed pattern that has been dovetailed has to be altered. American patternshops use dovetails where an ordinary butt joint would suffice; nothing is better, in the case of boxed patterns, than to cut checks or recesses in sides 3/16 in. or $\frac{1}{4}$ in. deep, which prevent the ends from being knocked in.

The most common use for the dovetail in patternmaking is for the joining of loose pieces, and this is quite different from the ordinary dovetail joint. In joining the ribs connecting the valve seats to the outer wall of metal of globe valves, the dovetail joint is undoubtedly the best, but this is a different joint from the carpenter's joint.

Very few patternmakers have a knowledge of joints comparable with the carpenter or cabinetmaker. There are several types of edge joints employed, the butt joint being the simplest. A tongued joint is always to be preferred to a plain butt joint. The carpenter uses machine-tongued timber, but not so the patternmaker. At one time tongue and groove planes were used, but in most shops now there is a fine circular saw on which both tongue and groove can be formed. A very satisfactory alternative to the tongued joint is the dowelled butt joint. When it is intended to work up a broad surface without battens, the dowelled butt joint cannot be beaten. There are, of course, two alternative methods of marking the dowel centres, the one being by square and gauge and the other by means of ordinary household pins. The first method is the more accurate. Care should be taken that the dowels are shorter than the bored holes, and a tip worth remembering is to pierce from the timber surface to the root of the bored hole, as this provides an outlet for the compressed air; if this is not done there is always a possibility, even when a joint has been glued, of the compressed air forcing the joint open.

The mortise and tenon joint is seldom used in the pattern shop. For framing-up and for covers the half-lap joint is superior, for patternmaking purposes, to the mortise and tenon, and much more easily made. Where a large number of castings are required, it might be worth while to use the mortise and tenon joint for some frames, but it is doubtful; half-lapped frames will stand a lot of abuse. The conditions under which they are used are altogether different, of course, to other kinds of timber construction. When a pattern consists of a flat frame on which are facings and ribs, then the mortise and tenon joint would appear to be superior to the half-lapped joint.

There is always the difference between pattern work and other forms of woodwork that accuracy is essential with the former, and this necessitates the finishing of joints with plane and chisel, whereas the carpenter finishes with the saw; it is the chiselwork that takes time, and dovetails or mortises for patterns involve much more labour than when they are made for other purposes.

Casting Design.*

By F. C. Edwards.

Every casting is born with a dual personality —form and material. Upon the nature of these twin fundamentals depends the serviceableness of the casting for its intended purpose. And, since castings are designed for purposes varied as the poles apart, and innumerable beyond computation, the changes required to be rung upon these basic attributes are kaleidoscopic and illimitable.

Personality, of course, implies individual differentiation—separate entity. Applied to castings, the term means that for the highest satisfaction of each of the differing requirements for which castings are made, there is but one best combination of form and material.

Commercial production, indeed, demands more than this. Here we have to remember that service requirements *per se* are not the *alpha* and *omega* of casting design. There can be no entity without existence. And however admirably suited —on paper—the design may be for the ultimate purpose of the casting, if its translation into concrete form results in still-birth, or can only be executed at a prohibitive cost, then such design must be regarded as futile.

To wait until scrap, imperfect castings, or too costly production constrains attention to foundry requirements is the negation of all scientific method.

The successful designer of castings, then, must be adequately equipped with general foundry knowledge. Not only should he be able to anticipate each successive step in the moulding of his creations—which enables him to obviate snags and to select the path of least resistance for the moulder—but, since metal cast in moulds yields high- or low-unit strength, according to its form and relative position, he should be able to select, from several possible alternative designs, that which gives the maximum strength for a minimum expenditure of metal.

It will thus be seen that casting design differs fundamentally from that, say, of mild-steel structures. In the latter case, one is dealing with existing sections of metal, of a more or less isotropic nature, the strength of which is pretty accurately known, and with which, by the aid of mathematical formulæ, the engineer may build structures guaranteed to withstand the effect of certain calculated forces. In designing castings, on the contrary, there is not only to consider the technical and economic questions involved in bringing into existence required sections, and adapting the form of the respective sections accordingly, but there must be such a harmonious co-relationship between the various members of the component—with regard to section and mutual attachment—as will ensure, for the collective whole some reliable approximation to the strength of the metal employed as indicated by the test bar.

Casting Design from the Moulding Point of View.

Most castings are made in enclosed moulds. ("Open-sand" work, of course, need not here be considered.) To allow the pattern to be withdrawn, cores, if any, to be inserted, and pouring gates to be made, the moulds must be jointed. The number and position of these joints depend upon the design of the job as expressed through the medium of the pattern. How this medium may neutralise the effects of bad design (which it undoubtedly can do to a considerable extent), or how it can ruin good design (which it has been known to do) is not within the scope of the present Paper.

Generally speaking, the fewer the joints the simpler the job; incidentally, the less the fettling required on the castings. The designer should always keep this point in mind, especially when he is tempted to include in one component two or more members which could be more advantageously, and with less risk, produced as separate castings.

* A Paper read before the Sheffield Branch of the Institute of British Foundrymen, Eng.-Commander L. Jackson presiding.

Elimination of "Liftering."

The simplest joint is that known as the "flat" cope, shown at A, Fig. 1. This represents a section of a channel-shaped girder casting. In moulding this job, when the cope B is removed, since the whole of the pattern is in the bottom part, or drag, C, there is no risk of mould disturbance.

Compare the above with the joint required in moulding the H section girder as shown at D, Fig. 2. Here, extra work is involved in ramming up the job. And since the mould drops the depth of the recess E, below the joint of the moulding box, "liftering" would have to be resorted to. Again, in removing the cope, instead of it being clear of the pattern immediately it was moved upwards, the mould would require to be lifted the height of E before it was clear. If the pins, F, in the moulding box were not so long as this lift, or if they did not accurately fit the holes in their respective lugs, there would be the possibility of mould disturbance. This, of course, would entail mould repair, with its attendant risks of scabbing, imperfect or scrap castings. Moreover, if the top part were not returned to its original position (consequent, again, upon loosely-fitting pins) the two side ribs would be found, on the casting, to differ in thickness.

From these elementary examples, in which the design shown in Fig. 1 possesses many points of superiority (from the moulding point of view) over that of Fig. 2, it would appear that the primary question for the designer—as it is for the moulder—should be: "Where best to joint the mould?" This, indeed, is the foundation-stone, and although it would be absurd to expect any but the simplest castings to be arranged to give a flat cope joint, it cannot be over-emphasised that a bias in this direction—where each detail exhibits the sympathetic impress—often leads to a very substantial saving in moulding cost.

Typical Cases.

Typical examples are illustrated by Figs. 3 to 7. Fig. 3 shows a bracket of very common type. Bosses G, to carry a shaft, are seen at each end. Now, leaving out of consideration the employment of dry-sand cores round the bosses (which, for several reasons, is bad practice, and involves core-making), such a job would be moulded as shown in Fig. 4. The mould would be jointed to bring half the pattern in the cope, necessitating a special box-part to accommodate the height, H, projecting above the joint. The withdrawal of the pattern might also lead to a damaged mould, which would require more or less repairing.

Incidentally, in cases where the close proximity of the boss to the plate reduces the width of the mould at J below, say, ¼ in., there is the added danger of its displacement by the molten metal. And where such displaced portions of sand finally come to rest a corresponding hole will be found in the casting. There is the further well-established fact that such fine projections of sand close to comparatively heavy masses of metal generate gases, which, finding their way into the casting, give rise to porosity. Mr. E. Longden, in particular, has proved this.

By carrying the boss down to the plate, however, as shown at K, Fig. 5, a perfectly flat joint is obtained. This means that an ordinary box-part, as shown in Fig. 1, can be used for covering the job. Moreover, since this box-part may be, say, half the depth of that required in the previous case, the work of ramming the job would be correspondingly reduced. Again, with the boss cast downwards, the soundest metal would gravitate to where its presence was most essential. The shallow end facings, L, Fig. 3, would, of course, be made circular, and loosely wired or dovetailed in position. The internal D-shape bosses, K, would provide ample space for the removal of the facings after the pattern had been withdrawn.

The difference in the amount of labour required for fettling castings made, respectively, as shown

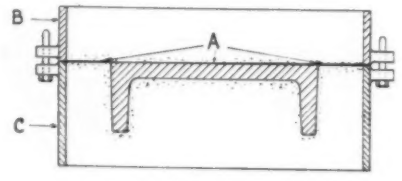

FIG. 1.

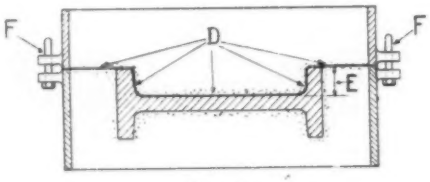

FIG. 2.

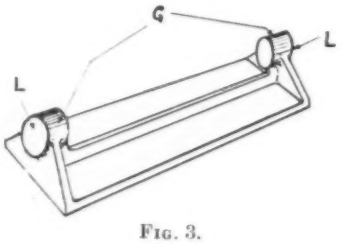

FIG. 3.

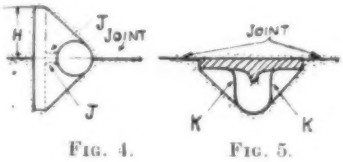

FIG. 4. FIG. 5.

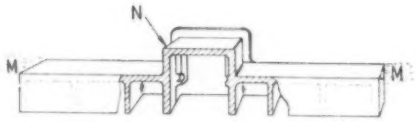

FIG. 6.

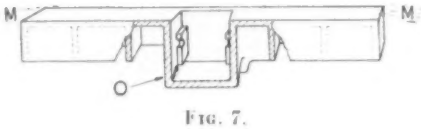

FIG. 7.

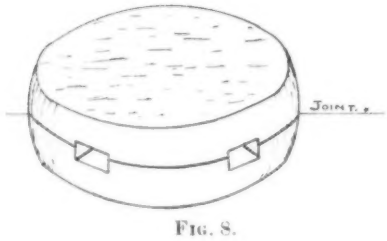

FIG. 8.

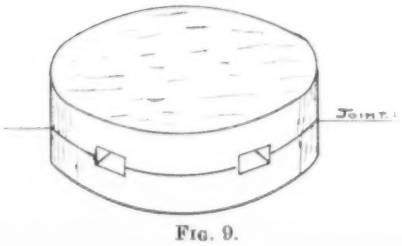

FIG. 9.

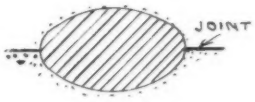

FIG. 10.

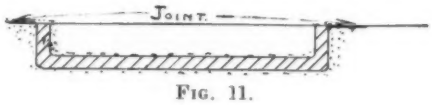

FIG. 11.

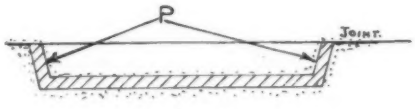

FIG. 12.

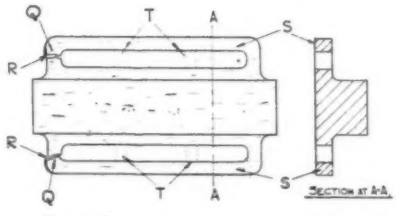

FIG. 13. FIG. 14.

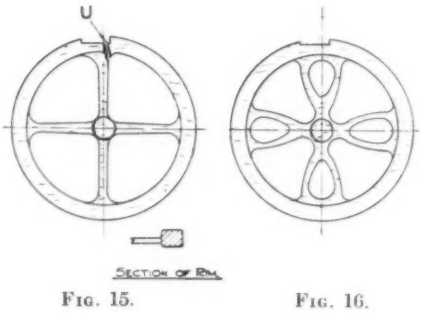

FIG. 15. FIG. 16.

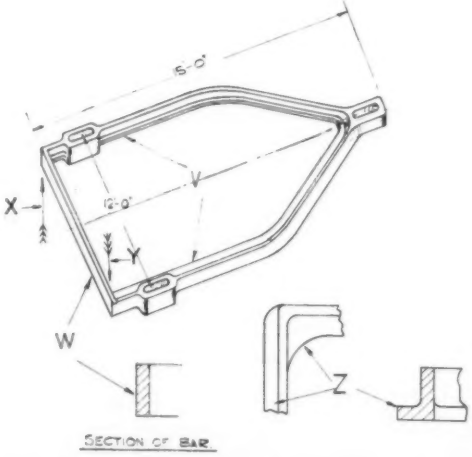

FIG. 17.

in Figs. 4 and 5, should also be noted. The former may entail as much as 50 per cent. more work than the latter. Indeed, loosely-fitting moulding box pins (not uncommonly met with in the ordinary foundry) may lead to rejects in the case of Fig. 4, through "crossed joints." Moulded as shown in Fig. 5, however, so long as the cope is down on the drag, it matters not how it is oriented.

A different example of the same principle is shown in Figs. 6 and 7. In each case M indicates the joint. These illustrations refer to side frame castings, 20 ft. long and 2 ft. wide. In each case the front plate is shown torn away the better to illustrate the job. The main purpose of this side frame, it may be observed, is to carry a pair of bearings enclosed in a central pocket. It is thus immaterial to the ultimate object of the casting on which side the pocket opens out in relation to the ribs. Nevertheless, it is a very material matter to the foundry, as a little consideration will show.

In each case, the pocket is cored out with an oil-sand core. Now it will be seen that with the pocket rising from the plate, as shown at N, Fig. 6, a very deep cope is required. This involves extra work in ramming and "liftering" the mould, when compared with that needed for Fig. 7. In the latter case, excepting a very shallow coreprint—say, $\frac{1}{4}$ in. deep—for positioning the core, the cope joint is quite flat.

With the pocket projecting from the same side of the pattern as the ribs shown at O, Fig. 7, it is moulded in the drag, and presents no special difficulty. The central pocket core, instead of being anchored down in the bottom of the mould, is then secured to the bars of the top part. In this case, again, the labour saved in the foundry may easily amount to from 30 to 40 per cent. And the risk of scrap is reduced, because the core cannot be floated out of position by the hydrostatic upward pressure of the molten metal, as is possible in the case of Fig. 6.

Incidentally, the bearings in the case of Fig. 7, being situated in the lower part of the mould, are more likely to be clean and sound than those in the upper regions, as in Fig. 6. For as the metal passes along the bottom and sides of such a mould a considerable amount of sullage is bound to be picked up. This sullage, together with any dross in the metal, rises to the top, and in the case of Fig. 6 would naturally come to rest in some part of the projecting pocket.

Where the flat top joint is inadmissible, on account, say, of brackets or cores in the side of the job, a slight convexity from the joint line will often considerably facilitate moulding. A simple example is shown in Fig. 8. This represents a casting with slot cores on the central plane. Now, with the joint as shown, the pattern would become increasingly clear of the mould from the moment the cope was lifted. The lower half of the pattern would similarly withdraw from the drag with the same immunity from mould disturbance. A further advantage with such design is seen in the ease with which the joint of the casting can be cleaned off. Compare Fig. 9, where the straight sides not only militate against easy pattern withdrawal, but would entail more labour in fettling in the case of overlapping joints on the casting, or if the side of the casting happened to be even slightly concave where the runner had been placed. With a curved side, as shown in Fig. 8, such an indentation is, as a rule, easily bobbed out.

Another adaptation of the same principle is that of the elliptical-section arm (Fig. 10), as used for wheels, etc. Such a section is easily moulded; with its "stream-line" contour it forms an ideal channel to convey the molten metal from rim to boss, or *vice versa;* it exposes no sharp corners of sand to wash away or to generate gas; the joint, if any, on the casting is easily cleaned off; finally, it provides an ideal surface for the reception of paint or enamel on the finished component.

Where a ribbed plate (Fig. 11) is to be cast face-downwards, to secure, say, a perfectly clean surface, the ribs should be inclined outwards if possible, as seen at P, Fig. 12. This ensures a clean lift in the cope, as well as allowing the pattern to be removed from the drag without risk of mould disturbance.

Metallurgical Aspect of Casting Design.

Here the controlling factor of design is the well-known diminution of volume which occurs whilst a casting is passing from the molten state through the various successive stages of cooling. This diminution of volume, known as contraction or shrinkage, affecting as it does each individual member, as well as the casting as a whole, and operating in various directions, sets up a play of forces more or less in opposition to each other, which may weaken, even if they do not fracture, the casting.

To anticipate the action of these internal disruptive forces is as much the business of the designer as it is to calculate the external forces to which the casting is likely to be subjected in service. Indeed, this must ever be a basic condition of sound design—the hinge pin; for if castings are not internally self-supporting, how can they be expected to carry external loads!

It is not suggested, of course, that ordinary castings can be produced entirely free from internal stress. Such a view would be as Utopian as to expect absolute purity of metal. In all but the simplest castings, some degree of stress must ever be expected. Here the designer's task has its parallel in that of the metallurgist; to overcome their respective *bêtes-noirs* they must continually have recourse to suitable antidotes.

The best-known insurance against shrinkage stress is uniformity of section throughout the casting. This becomes clear from a consideration of cooling phenomena. Take two castings—one with its members of equal section of metal, the other of which the members differ appreciably in size. In the former case, since shrinkage proceeds *pari passu* with cooling, and since, in the early stages of cooling, the metal is more or less plastic, the action that takes place on the part of the members towards a reduction of their respective lengths, being simultaneous, permits of a general readjustment of form—a kind of give-and-take action, which eases the situation all round. The degree in which this readjustment of form fails to satisfy each individual member's shrinkage requirements will measure the residual stress present in the casting.

When, on the other hand, adjoining members differ appreciably in size, that of lighter section naturally cools and shrinks first, and thus assumes rigidity of form and a definite length in advance of the heavier section. Mutual adjustment then becomes difficult, if not impossible; stresses are set up in consequence; and the intensity of such stresses will largely depend upon the extent in which the adjoining members are out of shrinkage step one with the other.

To the practical foundryman, of course, these principles relating to cooling stresses are elementary. From time immemorial he has had to uncover heavy sections of metal, or to resort to chills, in order to equalise cooling rate throughout castings. Bitter experience has taught him these things. With greater reason, then, should they be broadcast, so that all who are privileged to design castings may realise the importance of even sections of metal. A suitable slogan, indeed, for the designer would be: "To lower the safety factor, keep the section uniform."

An example of the effect of differential shrinkage is illustrated in Figs. 13 and 14, which represent plan and section respectively of a grey-iron casting having light side wings connected to a comparatively heavy body. When the casting was taken from the mould it was found to be fractured as shown at Q. Very significantly, the fractured part of the side strips projected beyond that of the centre body. This difference (shown at R) amounted to about $\frac{1}{16}$ in.

The case aptly proves the differential shrinkage stress theory enunciated above. The side bars, S, would naturally cool first; they would assume a definite length whilst still connected to the body of the casting. The latter, in cooling and shortening, would gradually induce a compressive stress in the bars, and the connections, Q, would be placed under a shear stress. The quality of the metal would then determine the occurrence of fracture.

The remedy was found in connecting up the outside bars to the centre body at two more points—shown dotted at T. Such connections, of

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course, would feed the outer strips with heat from the centre block, and, by tending to synchronise their respective rates of shrinkage, they would materially reduce the growth of stress at the end connections.

A somewhat different case, but one in which the same principle is involved, is illustrated by Figs. 15 and 16. Fig. 15 represents a ring, 12 in. in diameter, connected to a central boss by four straight arms of lighter section. A number of these castings were made and delivered (apparently quite sound) to the machine shop. As each casting was being machined, however, the rim fractured at the slotted part U.

Similarly, as in the previous case, the light arms would cool and become rigid before the rim had reached its limit of shrinkage requirements. The arms, in fact, would act as stretchers between their respective sides of the rim. The later-cooling rim—involving further contraction—would place the arms under a compressive stress, and would itself be in tension consequent upon its inability to assume the reduced diameter necessitated by the normal contraction of the metal.

In this case, an alteration in the shape of the arms, similarly as shown in Fig. 16, secured the desired result. It will be noted that in place of the rigid bars the arms are bow-shaped. This form easily lends itself either to extension or compression, especially whilst the metal is plastic. And even though the change of form were insufficient to satisfy completely the shrinkage requirements of the rim, such arms would impart to the component a degree of flexibility sufficient to enable it to withstand any ordinary shock of machining, etc.

Shock-resisting Properties.

The inferiority of castings to withstand shock—as compared with wrought materials—is another important phase of design. That this weakness can, to all intents and purposes, be effectually overcome, actual practice abundantly proves.

What foundryman has not met with examples of castings broken, say, in handling or machining operations, where, after suitable modifications in design (suggested by the fracture) no further trouble has been experienced. Admittedly, these are cases where one is "wise *after* the event." Nevertheless, they prove that shock-proof castings can be produced. Such cases, indeed, provide the most unassailable arguments for the closer study of casting design. For if a repetition of fracture can be prevented, why should it not be anticipated!

It is not, perhaps, so much a question of calculating possible service loads as it is the visualising of the incidental stresses to which the casting predisposes itself by some peculiarity of its required contour. A case in point is illustrated by Fig. 17. Here two side arms, V, are connected at the wide end of the casting by a plain bar W. A casual inspection will show that such a bar would be likely to fracture, say, in transit under torsional stress. This would follow, of course, if the arms were not lifted simultaneously. One can imagine one arm being wrenched upwards in the direction of arrow X, and the inertia of the opposite arm producing a stress similarly as indicated by the arrow Y. The onus of maintaining equilibrium would then be thrown—or rather jerked—upon the connecting bar W.

The bar is of a plain, rectangular section, and so far as service loads alone are concerned, it is of quite ample strength. This would not exonerate the designer, however, if such a casting, tested in service and despatched to its destination, should return after a few days labelled "Broken in transit!"

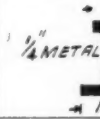
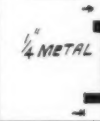
For a well-designed casting should be equipped to withstand the world's ordinary rough usage as well as to carry out its own special functions.

Now if it is remembered that even the best cast-iron gives but a comparatively limited range of deflection before fracture, we shall see that the plain, rectangular bar is unfitted to withstand the torsional stress above referred to. By an elementary law in applied mechanics, however, it is known that the addition of a longitudinal side rib to a rectangular-section bar increases the latter's resistance to a bending moment very considerably. According to this theory, one may render this casting immune from the effects of shock due to handling in transit by adding a flange to the bar, thus converting the rectangular into an angle section, and by the insertion of large-radius corner plates connecting the bar to the side arms—both shown at Z, Fig. 17.

A much-neglected aspect of casting design is that dealing with the relative strengths of various sections of metal. It does not seem to be sufficiently realised, for instance, that the employment of light, ribbed sections, where practicable, in preference to heavy, mass sections may mean a very material increase (sometimes as high as 50 per cent.) in the unit strength of the metal employed.

In this connection the results of a few simple experiments recently carried out at the works of Messrs. W. & T. Avery, Limited, Soho Foundry, Birmingham, may prove of interest. Castings of bars 14 in. long and of the following respective sections were made in green-sand moulds of the same light-general grey-iron mixture (3.0 per cent. silicon). These were subjected to an ordinary transverse test on centres 12 in. apart. The results are given in Table I.

TABLE I.—*Weight and Strength of Varying Sections.*

No. of Tests	Section	Weight	Breaking Load, Tons
1		7lb. 14oz.	4·0
2	"	"	4·41
3		3lb. 6oz.	3·5
4	"	"	3·41
5		3lb. 6oz.	3·71
6	"	"	3·86
7		3lb. 6oz.	3·79
8	"	"	3·80

From the above it will be noted: (1) That the lightened sections, although less than half the weight of the solid rectangular bar, carried almost the same load before fracture as the solid bar; (2) that whereas, in the solid bar, there was a difference in the breaking load of the two bars tested of 0.4 ton, the breaking loads of each separate pair of lightened bars were practically identical.

In the first pair of lightened bars (Nos. 3 and 4) the top and bottom flanges, as tested, were the same width, namely, 1 in. The top flanges of the second pair, in compression as tested (Nos. 5 and 6), were reduced to ½ in. in width, and the bottom flanges, in tension as tested, were widened to 1½ in. This, of course, enabled the greater load to be carried as shown, whilst maintaining the same weight of metal in the bar. In the third pair of lightened bars (Nos. 7 and 8), the bottom flange, in tension as tested, was brought back to 1 in. in width, and the bar was deepened to the extent in which the top flange was reduced, viz., ½ in. This deepening of the bar similarly accounts for the higher breaking load.

The economy of metal secured by the employment of the lightened bars amounts in one case to 57 per cent. of that employed in the rectangular section. The uniformity of their breaking loads (perhaps the most significant feature of the tests) undoubtedly implies greater reliability—the one essential if confidence in the employment of castings is ever to be established.

Oil-Sand Cores and Production.*

By W. West (Leyland Motors, Limited).

The application of oil sand as a means to foundry production has been by this time definitely confirmed in everyday practice. The ease with which the sand mixtures can be made, and the subsequent baking, are factors admirably suited to foundry work in general, and of which no foundryman need have any doubts as to success. It is, however, of the utmost importance among the practical details of oil-sand preparation that a suitable mixing vessel be used, to ensure an even distribution of the oil over the sand grains. The ordinary paddle mixer to be had on the market to-day is well adapted for the mixing process, but in some cases where the addition of certain gums are made, which are necessary for intricate and overhanging types of cores, the maximum amount of green bond will be obtained by passing the mixture through mullers of medium weight. It is generally recognised that ordinary shore sand is of excellent quality to meet the necessary requirements, the grain size being of a finer mesh than that of a river sand, a better finish is obtained on the surface of the casting, at, incidentally, a very much lower cost. Little or no serious disadvantage is experienced from the presence of salt, nor yet from the small pieces of sea shell that are distributed among the mass. Where cores are required to take positions in which they are more or less surrounded by liquid metal, it is advisable to make small additions of an open-grained sand to ensure permeability.

Much discussion has arisen from time to time concerning the condition of the sand, whether such should be dry or damp. The answer depends very much upon the facilities to hand, the layout of the plant, and the object to which efforts are being made. If the work to be executed is not of a repetition character and of only limited quantity, when the laying down of the necessary drying plant would not be warranted, then the use of damp sand is not of any great moment, but may, if wisely handled, prove to be a factor of economy and a means of making the core more permeable to gas, through the evaporation of the water vapour.

Production of repetition castings, however, calls for dried sand, the degree of dampness is an indefinite and variable factor which tends to cause irregularities in the resultant cores. In addition to this, the accompanying prolongation of the drying time, owing to the amount of water present is a definite impediment to output, the loss of which may possibly amount in actual cost to more than that entailed by the initial drying.

Essential Properties.

Most of the required properties of an oil-sand mixture are well defined, and successful results from the use of it depends upon the character of the individual items constituting the mixture. Perhaps the most important of these items is the type of core oil used, for success or failure is chiefly governed by its character and behaviour. The oil should possess a composition calculated to give the maximum of bonding power between the grains of sand; after drying the film thus formed should be capable of resisting the effects of moisture, when the core is allowed to stand in the open during a protracted period. One other salient property required is the rapid disintegration of the core after solidification of the metal, to allow the casting the greatest freedom in contraction, while from a production point of view, the shorter the time necessary for drying, the more suitable will be the core mixture. No part of the making of oil-sand cores is more important than, after selection of the oil, to give the mixture a suitable heat treatment, for upon this depends the correct functioning of the various constituents.

It is proposed, therefore, to deal more specifically than usual with the character of the core oil and its subsequent drying in order further to explain some of the basic principles which are involved in the process.

The choice of an oil is generally decided upon by the evidence of its physical properties, for it is of first importance that it should be of such a fluid character that a perfect covering of the sand grains is obtained with the minimum mixing. Apart from this factor, the remaining properties of a sand mixture is bound up with the chemical composition of its constituents, and, from a study of the many types of oils and their respective compositions, it is evident that every oil is not suitable nor capable of producing oil-sand for foundry use.

Classification of Core Oils.

Broadly speaking, the better-known oils, and those whose prices bring them within the scope of foundry interest, can be divided into three distinct groups according to their respective source of supply:—(1) Animal oils; (2) mineral oils; and (3) vegetable oils.

Animal Oils are well represented by such examples as whale oil, cod-liver, and sperm oil, etc. They are of interest only, for while they have the necessary qualifications for core making, the offensive smell of the fumes emitted during the drying process make their use distinctly objectionable.

Mineral Oils are found free in nature as petroleum or distilled commercially from oil shale. Certain members of this group have very low flash points, and are exemplified by petrol and benzoline, while others with higher flash points are paraffin, lubricating and machine oils. These are useless as binders because of the form of their constitutions, which have no power to dry under the effect of time or temperature.

Vegetable Oils, however, are of the utmost importance, for they include many of those oils which are of the greatest service to foundry practice. The members of this group are composed of triglycerides of unsaturated organic acids, and it is upon the saturation of these by the absorption of oxygen of the air that they possess the peculiar property of drying under the influence of temperature and time. The group is generally divided further in three classes, according to their drying power, when left exposed to the air in thin films at ordinary temperature:—(1) Drying oils, *i.e.*, linseed, hempseed, and poppyseed oils; (2) semi-drying oils, *i.e.*, cottonseed, soya bean oils, etc,; and (3) non-drying oils, *i.e.*, rape, castor, and olive oils. Thus a non-drying oil like rape oil will remain fluid under atmospheric conditions for an indefinite period; linseed oil, belonging to the drying class, will set to a tough elastic film within a few days; while semi-drying oils like cottonseed are between the two classes.

This distinction in drying properties, there is reason to believe, is entirely one of degree, for Livache (Compt. Rend. 1895) points out that all fixed oils, vegetable or animal, are capable of setting to an elastic filament, similar to those yielded by the drying oils, if left sufficiently long at higher temperatures than atmospheric.

It will be evident, therefore, that a core oil may consist of one particular oil, or perhaps several, which may or may not be entirely vegetable, but, if so, may originate from different classes of the same group. It is of distinct advantage when production is one of the main features that the oil or oils in use should be entirely of the drying class of vegetable oils, which will produce, other things being equal, the maximum number of cores in the minimum time.

The Properties and Character of Linseed Oil.

When exposed to the air linseed oil gradually absorbs oxygen from the air, and assumes finally a dry or gelatinous mass known at linoxyn; the reaction is accelerated under increase of temperature within defined limits. It is on account of this peculiarity that it exhibits the binding together of sand grains in an oil-sand core during drying. It is therefore important to notice that the drying property of an oil is clearly indicated

* A Paper read before the Burnley section of the Institute of British Foundrymen, Mr. Barnes presiding.

by its power to absorb oxygen: so that if it were possible to determine the amount of oxygen which any oil was capable of absorbing in a given time, we should be able to enumerate the various kinds according to their respective drying powers. A direct method for this measurement is not yet possible, but valuable assistance is rendered by the fact that the unsaturated acids in the vegetable oils which take up oxygen, also absorb

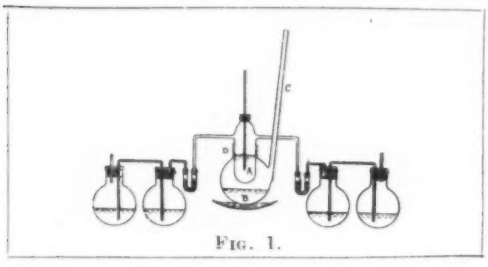


FIG. 1.

iodine to a similar degree in the presence of a third substance like carbon tetrachloride, so that an estimation of the iodine absorbed by any oil is an indication of its drying power. To this end the amount of iodine absorbed by a definite weight of oil, fixed at 100 grammes, is expressed as the iodine value.

TABLE I.—*Iodine Values of Various Oils.*

	Iodine Value.		Iodine Value.
Linseed oil ...	185	Sunflower oil ...	125
Chinese tung oil	171	Maize oil	120
Hempseed oil ...	153	Cotton seed oil ...	105
Poppyseed oil ... (Slide No. 1)	136	Olive oil	95
		Rape oil	95
Soya bean oil ...	125	Castor oil ...	85

Of these more common vegetable oils the first four exhibit marked drying properties; the next four are semi-dryers; while the remaining three are of the non-drying type. In each case there is a definite decrease in the iodine value as we pass from the drying to the non-drying oils.

It was Hazima (Zeitsch Angen, 1888) who

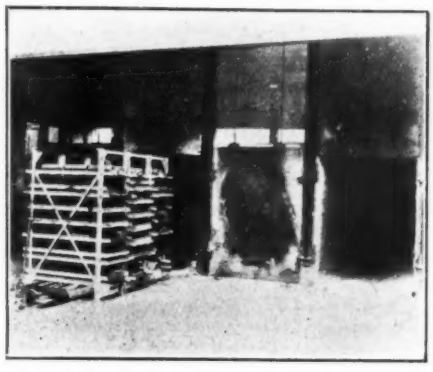


FIG. 2.—CORE STOVE AND RACK.

first pointed out that the iodine value of an oil rises with its drying power.

It would appear, therefore, that the use of an oil having a high iodine value in the untreated sample will give the quickest drying results. It is significant from the position which linseed oil occupies in the foregoing list, that its great popularity as a core oil and a core oil base is not by any means misplaced.

Changes During Drying.

Additional reactions take place during the process of drying, and it becomes necessary to an understanding of these.

Krumbaar (Chem. Zeit, 1916, 40, 937) has shown

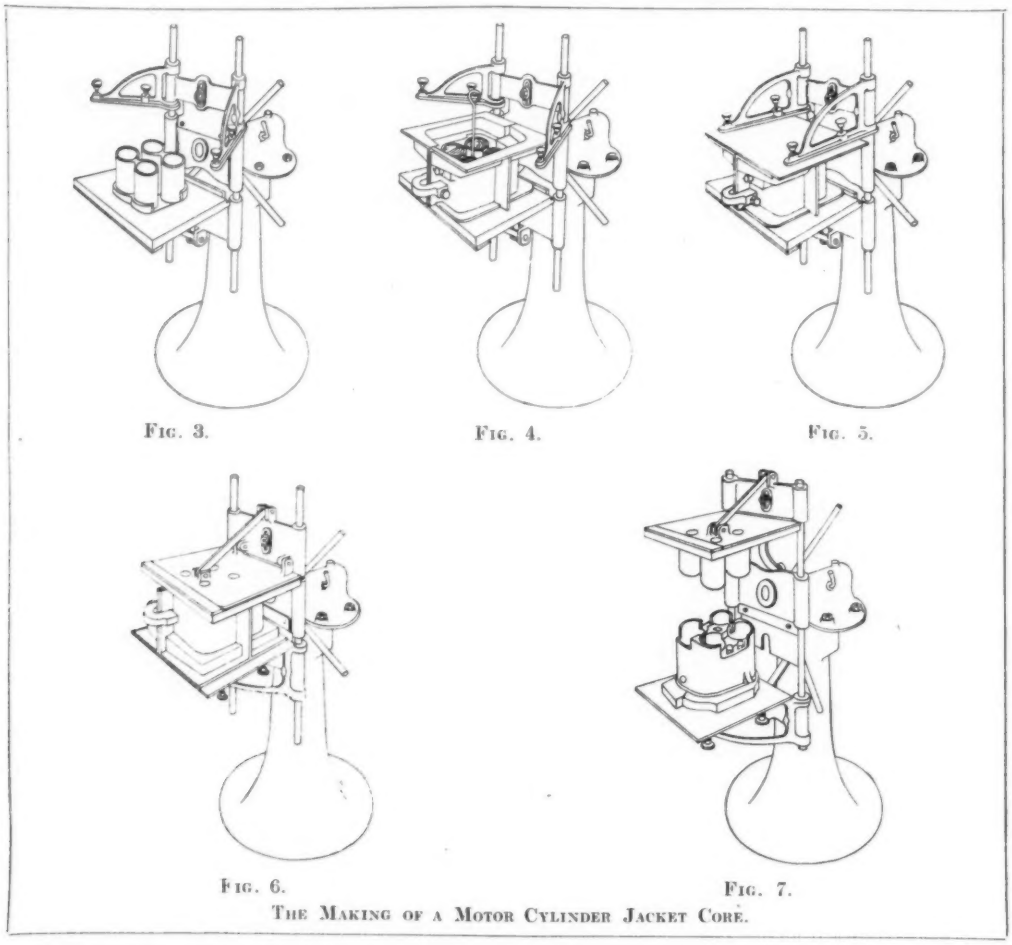


FIG. 3. FIG. 4. FIG. 5.

FIG. 6. FIG. 7.

THE MAKING OF A MOTOR CYLINDER JACKET CORE.

in his results of experiments that when linseed oil is heated to definite temperatures in an atmosphere of carbon dioxide the figures shown in Table II were obtained.

TABLE II.—*Krumbaar's Experiments on Linseed Oil.*

Temperature in deg. C.	Duration of heating in hours.	Relative viscosity.	Iodine value.
		Std. 1.00	Std. 175.0
200	20	1.13	168.7
200	40	1.35	160.1
260	15	2.35	145.6
260	30	7.96	108.0
300	10	115.0	120.4
300	20	not flow	76.3

The direct fall in the iodine value suggests that some action takes place in which oxidation has no part, but as the temperature increases with a prolongation of time the oil thickens up to the degree that it will not run, as indicated by the relative viscosity.

Fahrion (Zeitsch Angen Chem. 1892.5.17) suggests that this action was one of polymerisation, that is, inter-molecular changes take place whereby the number of atoms in the molecule of the oil increases to some multiple of their original number.

In this direction the experiments of Dr. J. N. Friend (S. O. & C. Chemists, Vol. 7, No. 49), in which the author had the privilege of assisting, are of great interest, showing as they do that polymerisation of linseed oil is at first quite definitely marked at 250 deg. C.

In these experiments the pure raw linseed oil was heated in glass vessels at temperatures ranging from 50 to 250 deg. C. To maintain the temperatures below 100 deg. C. the vessels were immersed in a water thermostat, maintained at a constant temperature. For higher temperatures the apparatus as shown in Fig. 1 was designed, and proved entirely successful. The whole apparatus is made of glass, the oil being placed in A and an air condenser fixed directly on to B, whilst D is a ground-glass joint to avoid trouble with cocks and rubber connections. Heat was applied through the medium of a sand bath over a Bunsen burner. To exclude the possibility of oxidation, the vessels were filled with nitrogen by drawing air first through flasks containing alkaline pyrogallol, which liquid absorbs the oxygen, allowing the nitrogen to pass through. Table III gives a few of those obtained from the experiments.

TABLE III.—*Heat Treatment of Baltic Oil Four Years Old.*

Temp. in deg. C.	Duration of heating in hours.	Density at 20 C.	Iodine value.	Relative viscosity.	Mol. weight.
Original	sample	943.9	167	100	829
50	100	943.8	164	86.6	833
50	250	945.5	166	122.8	833
80	100	944.5	161	128	868
134	50	949.6	157	156	875
218	50	946.9	153	190	950
250	25	951.4	120	1,050	1,174

Any attempt at a detailed discussion of these results would be entirely outside the scope of this Paper, but it is distinctly interesting, from a practical point of view, to notice that a definite change in all the factors begins at 250 deg. C., and this point therefore provides a definite index as to the changes during the drying process.

To recapitulate, it has been found that the bond of an oil-sand core is a tough elastic compound formed by the oxidation of certain unsaturated acids which compose the constitution of the oil, together with its subsequent polymerisation under the influence of temperature and time. A measure of the presence of these constituents which are responsible for the formation of the film bond can be obtained from the respective iodine value of the oil. The present degree of published knowledge points to the high value of linseed oil as a binder, from the point of its drying properties; also from the high value of the film bond which it produces.

It has been indicated from results of experiments given that a temperature of 250 deg. C. brings about changes in the core oven which must have some bearing upon the ultimate result. In practice this has been amply confirmed by the writer, for with one of the drying of the vegetable class, *i.e.*, linseed oil, successful results are being now obtained quicker and better, the ovens being kept at a temperature not below 250 deg. C. and not exceeding 300 deg. C.

These temperatures are in accord with many figures which have been published as indicating general practice, and it would therefore appear to be confirmed that polymerisation which takes place at this temperature has a definite bearing upon the subsequent results.

Drying Process.

On the subject of drying or baking of oil sand the variety of arrangements for handling and the types of ovens in use are innumerable, both factors being determined by the nature of the work in hand principally and the circumstances under which this is executed. From production point of view, however, it becomes necessary that the amount of handling should be reduced to a minimum, the type of furnace be such that an even temperature can be steadily maintained, and that access in and out the oven should be of the simplest character. Fig. 2 shows a battery of ovens having these conditions in a foundry producing repetition work on medium production. The battery as shown is heated directly from a coke fire, the products of combustion being boosted from the firebox to the furthest extremity of the ovens by a well-regulated air supply proceeding from a 2 h.p. electrically-driven fan. The ovens themselves are separate and independent, the closing of two small dampers being sufficient to isolate any oven individually from the live flue which connects directly to the fire grate.

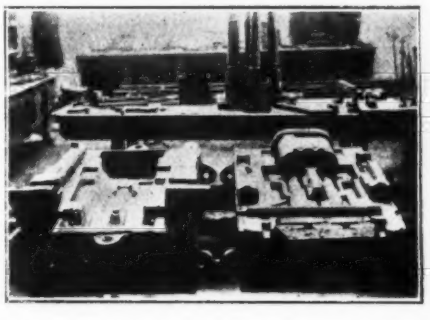


FIG. 8.—COMPLETE MOULD FOR A TROJAN CYLINDER.

The opening of the flues allow the hot gases to rise and pass through the entire breadth and length of the oven, and out again into the outlet flue which is common to all, but from which each can be individually isolated. The charges of oil-sand cores are carried on special racks made suitable to accommodate the various sizes of plates upon which the cores rest and the differing heights of the cores themselves. These racks are of the utmost convenience, insomuch that they are of light construction, easy to handle and, like the ovens, are strong and durable. The system of working is to have one of these steel racks within turning reach of two or three core-makers, according to the class of work, so that as each core is made and turned out on to a suitable metal plate which is at once and without double handling placed in the precise position for drying. From a production point of view this is ideal, and definitely means a saving of labour, greater satisfaction to the core-makers, for their will-to-work is thereby greatly increased by an apparently small convenience.

Two of these racks are required to make a charge for any one oven, so that when this number are fitted with cores, a small portable transveyor is wheeled into position, and by the action of a few pumps of the handle the rack is lifted from the ground and run into position in the oven. To lower the rack it is merely necessary to press a release lever with the foot, the oil passes from the pump cylinder and the descent is accomplished.

Each rack will accommodate approximately 25 cwts. of sand cores, and with a good regular temperature of 260 to 280 deg. C. the two racks

are ready to withdraw in 1½ hours from the time of insertion.

Methods of Application for Production.

When the extreme conditions are visualised under which castings, ferrous and non-ferrous, are produced, together with the innumerable number of shapes and sizes, it seemingly becomes impossible to deal with the subject of oil sand and its application to these manifold practices. The range of application, however, cannot be limited, for as it is of universal service to the foundryman, each in his sphere of activity, so will methods be devised differing according to the ideas and initiative of the individual, and the character of the work to be undertaken. It will, therefore, occur to the thinking mind that any attempt to outline individual shop practice, as in the following illustrations, is merely an additional expression of opinion.

Production, therefore, can be equally accelerated by methods of application, as well as the use of oil sand, and in Fig. 3 is illustrated one method of making a motor cylinder jacket core. For this

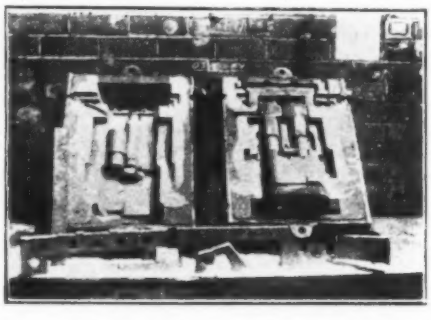


FIG. 9.—TROJAN CYLINDER MOULD AND JIGS FOR CHECKING DIMENSIONS.

it is necessary to have a core mixture having sufficient strength in the green condition to maintain the required shape unassisted, and further, being entirely surrounded by molten metal during the process of casting, it is necessary that it should possess the maximum degree of permeability consistent with the required bond. The cores are produced by one man at the rate of 18 per day. To the cast-iron pillar of the machine the entire core box is pivoted, and is free to revolve a complete circle if required. The centre carries two stout rods upon which slide the top and bottom tables, both of which are operated by the movement of the four-handed lever on the pivot centre, and become automatically locked in the open or closed position. Fig. 3 shows the machine in the normal position stripped of its loose pieces to show the metal cylinders which form the barrel cores.

Fig. 4 is the completed core box ready to receive the oil-sand mixture: the outer shell is easily removed by an outward movement after releasing the clamp. After placing four small wooden plugs into the tops of the small barrels, the oil-sand mixture is rammed into the box to the half-way line, when four curved ¼ in. dia. wires are placed around the centre-piece to strengthen and take the weight of the jacket walls. Ramming is then continued until the top of the bore-formers is reached, when the wooden plugs are withdrawn and metal plugs substituted, so that their flat sides are coincident. Two additional iron loose-pieces are now put into position to form the core print necessary for fixing in the mould. The ramming is afterwards completed and four small vents inserted in the barrels.

Fig. 5 illustrates the completed operation of covering the core box with the necessary turning-out plate, and the arms swung into position preparatory to inversion. By means of four thumb screws the box and plate are securely clamped, and at the same time a perfect level is made to ensure a good draw.

The entire core box is now inverted on the unlocked pivot, and requires steady handling to balance around the dead centre. Fig. 6 shows this operation accomplished—and the new position is securely held by the automatic locking device. This latter arrangement consists briefly of a centre plate which carries the ends of two levers, the further extremities are attached to the top and bottom tables respectively, the shape of the levers being curved in such a manner at the point of attachment to the centre plate, that they pass over the dead centre. Fig. 7 shows the core stripped ready for removal. It will be noticed at this stage that the two cast-iron pieces remain at the

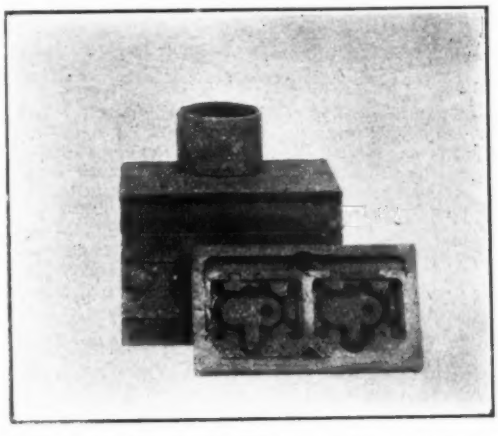


FIG. 10.—MAKING AN OIL PUMP IN STACK CORES.

base of the core: these are not removed, nor yet the metal plugs, which were inserted to form the top portions of the barrels in the position as shown, but are left throughout the drying period.

Fig. 8 illustrates the assembling of the complete Trojan cylinder with the jacket core in position, all the cores being made from various mixtures of oil sand according to their respective positions and functions. Each core, as it is fixed in position, is checked for dimensional correctness by the metal jigs shown in Fig. 9.

Stack Cores.

The question of production of small castings calls for special initiative from the foundryman, more especially when such depart from the plain, cubic or rectangular design, having undercut or hollow portions wherein hang various shapes of additional projections. The diminutive sizes add to the complication of the difficulties, for such types of castings under immediate discussion do not lend themselves to the suggested moulding machine. To make this possible, however, it would be necessary to block out the pattern extensively, and production to any extent worthy of the name could only be obtained by the use of several such patterns on the one plate. It is at this juncture

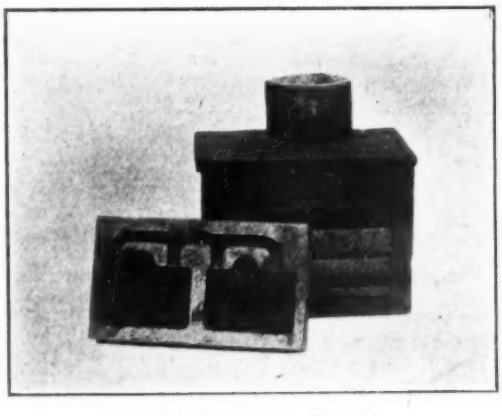


FIG. 11.—SAME AS FIG. 10.

that oil sand stack cores come as of very practical assistance to the foundryman.

Figs. 10, 11 and 12 show the method of making an oil pump consisting of three different parts. The entire cores are made in oil sand, each section of the stack when placed one upon another provides a complete mould with one common runner communicating by small sprues to two castings in each section, thus from only one stack twelve castings are obtained.

If a closer examination is made the open views will show that the middle and bottom portions of the pump are far from being simple castings, and, from the machine shop point of view, the few thousandths allowance for surface grinding being the only error allowance. Production when working on this principle is well maintained, for one core-maker alone is allowed for one stack of twelve castings a matter of two hours for the making and fitting together ready for casting, and is well able to produce his piece-work earnings.

Such examples as those which have been given do not by any means exhaust the potentialities of oil sand, and whether individual interests are centred upon large or small, steel, iron or brass castings, its unfailing qualities are found to be precisely the same.

It is by means of its application to the making of larger castings that the all-round advantages are obtained. The top half section of a turbine casing while not of great dimensions serves as an excellent illustration of the application of the "blocking out" system, which entirely supersedes the older method of "draw-backs" when such castings are made on a production basis. The under-cut portion of the casting when "blocked out" entails extra pattern making in terms of an additional core box. This is, however, well compensated alone by the amount of hand-moulding time which can be saved, irrespective of the possibility, that is distinctly evident,

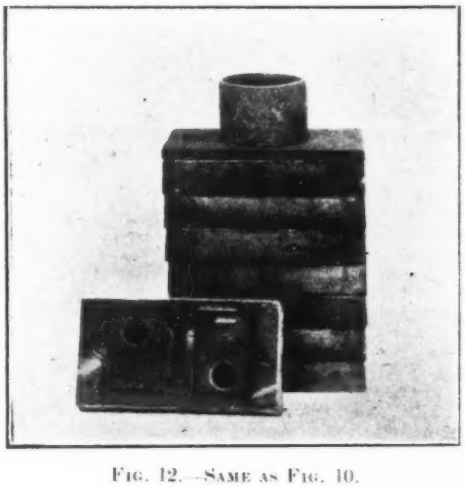


FIG. 12.—SAME AS FIG. 10.

of jolting up the mould to the upper ring on a moulding machine.

DISCUSSION.

MR. GLOVER asked for a rough idea of the relative costs of ordinary naturally bonded cores and oil-sand cores. MR. WEST, in reply, stated that in comparing any costs the decision depended not merely upon the initial price but rather the ultimate results one had in view. The higher primary cost of oil sand had compensations in the way of quicker production, handling conveniences, reduction on fettling costs, and considerably better finish internally of the castings. These advantages were not so marked when using ordinary sand. As to actual data he had not any at hand which he could give with accuracy, but felt sure from his own experience that oil-sand cores could be made to do all that was required of them as cheaply, if not cheaper than, other mixtures.

MR. HOWARTH asked if Mr. West had found that oil-sand cores sometimes gave way and sagged in the mould, even when chaplets were used, for ¼ in. metal sometimes came out ¾ in. metal in the top portion. He referred to a straight pipe casting 7 ft. in length and flanged at either end.

MR. WEST replied that cases had occurred, but he found that it was not due to sagging, for the use of chaplets in the bottom prevented that. The real reason was, that when the pipe core was made in halves, as described, a certain amount of subsidence took place during the drying in the oven, so that after pasting the two halves together the core would have been found eccentric had it been jigged. It became necessary, therefore, in general practice to allow ⅛ in. per foot for subsidence in the core-box.

MR. VERNON inquired as to the compositions of the various core-oils which were offered to foundrymen.

MR. WEST said that it was not possible on such an occasion to consider any proprietary mixture, but when once the basic principles of oil-sand mixing is assimilated, then any foundryman would be in a position to select the mixture best suited for his particular needs. It was always worth remembering that a straight oil, like linseed oil, has been well tried, and has been proved to be definitely reliable. Emulsions and creams invariably carried a large proportion of water in their compositions.

MR. MEADOWCROFT, after complimenting the lecturer, said he was particularly interested in the drying question. There had been distinct advances in the method of drying cores, but he always found that very good results were obtained by passing 20,000 cub. ft. of air through the ovens per hour to get the fine nut brown colour, and maintaining the temperature about 250 deg. C. This was not obtained if the temperature was too low. The necessary amount of oxygen was an important factor. He had found that the presence of salt was no detriment to making of oil-sand cores—it helped to bind the sand grains. He did not hesitate to say that the base of all oil-sand cores should be linseed oil.

MR. PELL asked if Mr. West had found difficulty in handling cores in the green state, which were made with an oil bond.

MR. WEST, in reply, pointed out that the addition of gums, resins, molasses in certain proportions to the mixture gave a good green bond, sufficient to enable the cores to be carried about without any difficulty.

Vote of Thanks.

MR. JOHN JACKSON, in proposing a vote of thanks to Mr. West, said he was most interested in the subject, because he had been through the Leyland Works and had seen the system of making cores there. The production of cores as outlined in the lecture was, he believed, only in its infancy, and he hoped that in the course of time it would develop extensively. MR. VERNON seconded, and the lecturer having acknowledged, the meeting then closed.

Catalogues Received.

Woodworking Machinery.—Messrs. Wadkin & Company, Green Lane Works, North Evington, Leicester, have devoted a 28-page catalogue to describing and illustrating their Semi-Auto Universal Wood Miller, yet nothing is repeated or overstressed. It is just a plain description of the machine and the operations of which it is capable of performing. It is, to our mind, an excellent example of good publicity work. It will be referred to long after the machine has been installed.

Welding Rods.—The Suffolk Iron Foundry (1920), Limited of Gipping Works, Stowmarket, in sending us catalogues covering their range of manufacturers, point out that two specialities—tennis requisites and mangles—are the outcome of a leader which we wrote in 1921, advocating that jobbing foundries should develop some speciality during slack times. We are pleased to learn that they are now quite an important line of manufacture for the Suffolk Iron Foundry. List N121 is a 12-page catalogue devoted to domestic mangles, whilst that devoted to tennis is a 24-page, two-colour brochure, mainly devoted to the posts. Some of the methods of anchoring these to the ground are very ingenious. The welding catalogue is a new edition of "Welding Cast Iron." It is a 32-page art production, which describes the various welding processes, and emphasises the advantages of acetylene welding, using ferro-silicon and "Supersilicon" welding rods. This particular catalogue is available to our readers on application.

Foundry Economics.

At a meeting of the Junior Institution of Engineers, on January 15, Mr. J. Wolstenholme read an interesting Paper on "The Commercial Side of Foundry Work."

In the course of the Paper the author said he had had some fifteen years' experience with the foundry side of an engineering business, and took a keen interest in all matters appertaining to the commercial side. In many cases the casting cost played a most important part in analysing the cost of engineering products. In his experience, no other section of the engineering trade had been so neglected as the foundry. In pre-war days probably 75 per cent. of the foundries of this country were hopelessly out of date. It was then generally the opinion that money spent on the foundry was wasted. During the war, and the boom following, it was suddenly discovered that, after all, the foundry had some place in the general scheme of affairs, and an effort was made by many firms to give attention to it. There was still much room for improvement. One difficulty was the impossibility of getting a good supply of trained or educated men to take an interest in the working of the foundry. The foundry had been worked, hitherto almost by rule of thumb, but that system was gradually being replaced. The cost of labour in the production of castings was generally much greater than the cost of raw material. Pig-iron cost about £3 15s. per ton, and the cheapest castings did not cost much less than £10 10s. per ton, while few could be bought under £14. Therefore, labour cost was of supreme importance. Foundry work was still an inexact science. The raw material varied in every delivery, the chief constituent of the coke used played a most important part in the final constitution and properties of the metal, and the moisture in the sand and even the weather all had a considerable effect on the castings.

Cost of Castings.

The cost of a casting was made up of the cost of the raw material, the cost of converting it into a state in which it could be utilised, the cost of melting the metal and delivering it into the ladle, the cost of moulding and core-making, the cost of dressing or fettling and the cost of selling. The cost of pig-iron or scrap was easily ascertained from the purchase book by taking the total amount purchased in a fixed period and arriving at an average figure. The percentage of loss in melting had to be deducted. This could be checked from time to time by letting the stock run as low as possible and weighing the amount in stock. The flux used per ton of metal varied very little. His cost did not exceed 3d. per ton. The cost of power, if the blower or fan were electrically driven, was easy to ascertain by means of a meter. It did not generally exceed 9d. per ton. It was sufficient to check this monthly. For depreciation 15 per cent. per annum for the cupola and 7½ per cent. for the blowing apparatus, cupola stage and hoisting mechanism was ample. The wages of men doing the unloading of the material and transferring it to the cupola was debited against the cost of melting metal. To sum up this portion of the work, he would give figures obtained in his own foundries:—Pig-iron, scrap, etc., £3 18s. per ton, loss in melting (3½ per cent.), 2s. 10d., coke per ton of castings (264 lbs.), 5s. 11d., flux per ton of castings, 3d., electricity per ton of castings, 1s. 3d., wages of men engaged on melting metal, 5s. 3d. per ton, depreciation 3s. 8d. per ton. Total cost of castings, for metal of furnace spout, £4 18s.

Cost of Moulding.

The cost of moulding and core-making was found by ascertaining the direct wages paid for each operation to the producer and adding percentages for indirect labour and material used. By indirect labour he meant management, staff, foremen, labourers, crane drivers, etc. A chart should be drawn up showing the relation of these percentages to the direct wages and this percentage should be adhered to. The cost of sand, chaplets and sprigs, electricity, etc., was taken out quarterly, and an allowance was made for rent, rates, taxes, depreciation, repairs and renewals and interest on capital. The figure thus obtained was reduced to a percentage on direct wages paid, and this, like the percentage of indirect labour, varied inversely as the direct wages. His figures for indirect labour varied from 42 per cent. to 68 per cent, and for materials from 36 to 49 per cent. The cost of castings for dressing varied inversely as the weight of the individual castings—the heavier the castings the less the cost of dressing. Piecework rates for dressers should be fixed at rates varying with the weight of the individual castings. A certain allowance was made for cost of selling and it should be kept within the allowance.

With regard to effecting economies, when scrap was cheaper than pig-iron the buyer would buy a greater percentage of scrap, and *vice versa*. As a rule, it was better to buy pig-iron ready broken, at a slight extra cost. The question of reduction in cost of transferring the materials to the cupola stage should receive careful attention. It was advisable to lift as much metal as possible at one time. A cupola melting two tons of metal per hour would melt it cheaper than one melting five tons per hour, assuming each had to melt, say, ten tons. The less the distance between the bottom of the cupola and the tuyeres the lower the consumption, owing to the bed charge being less. The oftener the furnace was slagged the lower the coke consumption. Every cupola should be fitted with slag holes and it should not be tapped out until metal showed at the slag holes. Any excess of air was liable to cool the molten metal while any diminution would not effect complete combustion of the coke. He found an ample supply of air at a low pressure was the most favourable. The correct bed charge could be determined from the time between the blast being put on and the first metal dropping at the tuyeres. Provided the fire had burnt through before the blast was put on, the metal being seen through the tuyeres would determine the correct bed charge for average conditions. It had been possible to reduce the quantity of coke per charge in many cases by 33⅓ per cent., without getting the metal too stiff to run. Careful attention to the temperature at which castings were run sometimes enabled considerable saving to be made in the cost of melting the metal. A high percentage of sulphur in the coke would cause trouble in the castings. He had known instances of two cokes varying over 33⅓ per cent. in specific gravity, and although the one was much cheaper per ton than the other, its value was much less, owing to its high specific gravity.

Piece Work.

A piece-work or bonus system was necessary to obtain economy by means of increased effort by moulders. The following were the results obtained, A on plain day rates and B on piece rates:—

	A	B		
	£	£	s.	d.
Value of castings produced	952	1,411	10	0
Cost of metal, plus melting	224	308	0	0
Direct cost of moulding	286	416	0	0
Indirect ,, ,, ...	163	181	0	0
Establishment and material charges .	135	144	10	0
Dressing charges	54	76	0	0
Total cost	£862	£1,125	10	0

The increase in value of castings on piece rates was 48.4 per cent., and the increased cost of moulding by 45 per cent. On the other hand, the cost of molten metal was only increased by 38 per cent., indirect cost by 11 per cent., establishment and material charges by 7 per cent., and dressing charges by 40 per cent. The total foundry cost increased by 30½ per cent., and the margin of profit increased from 10.4 to 25.4 per cent.

With regard to methods of moulding, machine moulding was the most economical, provided the capital expense, cost of maintenance, and operation were justified by the amount of work which could be done by the machine. He knew of cases where moulds were being rammed by machine in ten minutes where they were formerly rammed by hand in a day, but the machine and its sub-

sidiaries cost over £2,000. In practice, the difference between plate moulding and loose pattern mouldng was considerable. The plate moulder was paid about 10 per cent. less than the loose pattern moulder on day work, and the plate moulder was generally a more energetic worker and did not take such great care in finishing his work. It was not always necessary to use a full pattern in plate moulding. He remembered an instance where several 60-in. bore sluice-valve bodies and covers were made from a half-pattern, and the only item to set against a saving of £70 on the patterns was a charge of about £10 for plates, and the latter was also compensated for by the saving in moulding time. While greater economies resulted in repetition jobs from good patterns, some economy could be made even on skeleton patterns, provided a good class of plate moulder was available. If top and bottom boxes were not available, however, loose pattern moulding was probably more economical for odd orders. He suggested that foundrymen should seriously consider the merits of plate moulding. He had known cases where the moulding cost, from the same tackle, had been reduced by 50 per cent. by the adoption of plate moulding.

An ample supply of cranes was necessary in any foundry, and, generally speaking, the best method was overhead electric travelling cranes, with subsidiary jib cranes at intervals along the foundry. The electric cranes should be fitted with a dead-slow hoisting motion, and the lifting hook should move in a true vertical plane; they should be fitted with wire ropes, rather than chain, which was apt to wind over itself, with the result that, in lowering, a shock occurred when the chain was released, involving in many cases the dropping out of the sand in the moulding box which was being lowered. Motors, control gear and gearing should be totally enclosed.

Moulders should be given the best patterns consistent with cost, and the best moulding box for the job in question. Where the quantity of castings justified the preparation of special moulding boxes, the boxes should be made in the best possible form, always with an eye to using the same boxes at a future date for different work. All work not involving moulding should be done by labourers, and an attempt should be made to ensure that the moulder should commence work immediately he arrived in the morning, and continue to do so until closing time. In many foundries the labourers commenced work two hours before the moulder in order that the previous day's castings might be got away and the sand mixed for the moulder when he arrived the next morning. In others, the labourers worked in two shifts, viz., 6 to 2.30 and 2.30 to 10.30, while the moulders worked from 8 to 5.30. In many northern textile foundries each moulder was given floor space for two days' production, so that while he was moulding on one portion, the castings were being removed and the sand mixed on the other portion. The foundry should be worked, if possible, up to its full capacity. Boxes should be bolted, instead of weighting, as the former could be done easily by a boy. Two moulders should not be put on the same job unless it was a very large one. When additional men were put on they were more or less in each other's way.

Discussion.

MR. J. F. PETRIE, who presided, said his experience of ironfounding was gained in one of the 75 per cent. of hopelessly out-of-date foundries to which the author had referred. He proceeded to give some details of the inefficiency of the plant and equipment, and the unhealthy conditions that prevailed at the time to which he referred.

MR. C. H. WOODFIELD said, in regard to apprentices, the Federation had themselves to blame. When the lads were apprenticed there should be a stipulation that they should attend a technical school. He had made that proviso, and the boys did attend, and they took an intelligent interest in the business after the first year or so. He found that moulders simply did not want their environment improved. He had adopted a bonus system, and it had sent up the whole output of the foundry, and there was no management required. He would like to hear something further from the author with regard to the merits of open-bottom and closed cupolas.

The author said he had never experienced any trouble with the doors of the open-bottom cupolas, and, generally speaking, unless one wanted a mixing-well at the bottom, the drop-bottom cupola was far and away the best. It would require a Paper to deal with cupola practice alone.

MR. P. L. YOUNG also gave an account of his experience of foundry work, which ended twelve years ago. He said he soon got an increase in the output by reorganising the system of stock-keeping and by the provision of conveniences such as cupboards, etc., for the men. He also got an all-round reduction in the cost of electricity on the ground that work commenced at 4 a.m. He found it was necessary to have a camber on patterns to produce a straight casting. An economical blast in a 3-ft. cupola was 10 ozs. per sq. in. It was advisable to have the best material, if possible. The founders learnt to manipulate that, and as soon as it was varied one seemed to create disaster.

A hearty vote of thanks was accorded the author.

Aluminium Pistons Growing in Favour.

The aluminium-alloy piston for motor cars instead of cast iron is growing rapidly in favour, both by automotive engineers and the general motoring public, says Dr. Robert J. Anderson, consulting metallurgical engineer to the Kant-Skore Piston Company, Cincinnati, Ohio, and noted expert on aluminium. Dr. Anderson has made extensive studies of the performance of both automobile motors and aviation engines equipped with various kinds of pistons. The aluminium-alloy piston was first used in 1913, when certain automobile manufacturers in France and Belgium employed aluminium-alloy pistons for racing work. In 1914, with the advent of the world war, this type of piston was developed extensively for use in aviation engines. The introduction of the aluminium-alloy piston for general use in motor cars followed.

In the past few years great technical advances have been made in the design of the light alloy piston, and much improved alloys have been introduced. The question of clearances has now been satisfactorily worked out, and the aluminium-alloy piston has been demonstrated to be a thoroughly reliable and advantageous proposition, both from the point of view of motor-car builders and the general motorist. As compared with cast iron, the light alloy piston presents notable advantages in giving minimum wear and tear on bearings, long life, minimum collection of carbon on the head with no collection beneath the head, less oil and gas consumption, and very rapid motor acceleration. Heavy cast-iron pistons cause excessive vibration and wear in a motor. The aluminium-alloy piston weighs only about one-third as much as cast iron.

One of the greatest advantages of the light alloy piston is found in the high conductivity for heat of aluminium. The heat conductivity of this metal is about five times that of cast iron, while the conductivity of the usual piston alloy is about four times that of cast iron. This ensures cooler running of the motor and greater fuel efficiency. Practically all aviation engines and racing motor-cars are equipped with aluminium-alloy pistons, as practical experience and dynamometer tests have thoroughly demonstrated their superiority, Dr. Anderson pointed out.

The volume producers of high-grade motor-cars, like Chrysler, Hudson, Essex, Dodge and others, have decided upon aluminium-alloy piston in place of cast iron, and this piston is now standard on twenty-seven makes of American motor-cars. The replacement trade in aluminium-alloy pistons is very large and is still growing.

Aluminium-alloy pistons are now being used in motor-lorry engines much more extensively than formerly, and such pistons are ideally adapted for omnibus engines. Recently tests have been made with these pistons in Diesel engines, and the results were highly satisfactory.

XUM

The Institute of British Foundrymen.

BIRMINGHAM, COVENTRY AND WEST MIDLANDS BRANCH.

"The Melting and Pouring of Brass and Bronze" was the subject of an address by Mr. T. J. Bamford, of Birmingham University, at the December meeting of the Branch.

Melting and Pouring of Brass and Bronze.

MR. BAMFORD said that at the present time there were only two ways in which brass or bronze were obtained. One was by the direct admixture of the constituent virgin metals; the other by the mixing of old metals of all conceivable qualities and grades, with or without a certain amount of new copper and zinc or tin. The first was that which was followed when a very special mixture was wanted for a given purpose or to conform to some strict specification; the second was more generally adopted because it was cheaper to buy old metal than new copper or tin, while it was easier to mix old metal than new alloys. The non-ferrous foundry, unless it was in the exceptionally fortunate position of having a repeat order for a single alloy, such as 70:30 brass strip, must be prepared continually to be changing the composition of the alloy while it was casting. It was this feature, as well as the difference in the character of the materials used, which provided the essential differences between brassfounding and ironfounding. Speaking generally, the raw material was much more expensive in the non-ferrous foundry than in the ferrous. Spelter and lead were ten times, copper fifteen, and tin nearly sixty-eight times as dear as foundry pig-iron. Three important ingredients of the alloys—zinc, tin and aluminium—were easily oxidised, causing considerable losses of these metals by volatilisation during the melting process. A considerable degree of super-heat was required before pouring in order to produce sound, clean castings. The shrinkage of brassfounders' alloys was very large—roughly double that of common iron. In brassfounding, therefore, the minimisation of metal losses assumed great importance, the efficient utilisation of scrap became an economic necessity, and the rapid melting of the metals under accurate scientific control became essential if heavy losses of expensive metals was to be avoided.

Using Scrap Metal.

Referring to the utilisation of scrap metal, Mr. Bamford said that where scrap brass was not sorted when it reached the foundry it must be graded before use. While classification by colour of fracture into red, yellow and white brass normally served as a reliable guide to the copper and zinc content, it must be noted that alloys like manganese bronze had a whitish, close-grained fracture closely resembling the copper-tin alloys. The impurities likely to cause difficulty when scrap brass was re-melted were those elements which had been purposely added in former foundry operations with a view to removing oxides, adding fluidity or conferring special properties on the alloy. The chief impurities were iron, aluminium, phosphorus, silicon and lead. Iron, when present in red brass, formed small nodules of exceeding hardness and caused much trouble if the castings were machined, the little hard spots rapidly blunting the tools, involving much regrinding with consequent loss of time and expensive tool steel. Iron, when present in small quantities in yellow brass, was not segregated but acted merely as a hardener. In this condition the iron was not dangerous to tools and was, of course, added intentionally to such alloys as Aich metal, Sterro metal, and Delta metal. The brass, however, was more difficult to machine, and many cases of complaint from users of brass castings had their origin in the use in the casting shop of scrap containing iron. Iron filings, chippings, etc., could be detected with the magnet, and if the metal was hard when filed, the presence of iron in the alloy was suspected. A black, scaly appearance of castings made from scrap metal was a sure indication that it contained considerable iron.

Aluminium as an Impurity.

Aluminium was an undesirable impurity in scrap metals, since by reason of the formation of aluminium oxide which was not entirely removed the castings turned out unsound. Aluminium, when present in quite small quantities, produced a characteristic sheen on the surface of the castings—sometimes a very undesirable feature in making important bronze castings. The presence of aluminium could be detected by hard grinding on an emery wheel. Aluminium brass or bronze would heat greatly, burr over at the sides and abrade slowly. Phosphorus in brass scrap was not generally disadvantageous, but silicon was not suitable as a deoxidiser for brass or bronze, or for any alloy that contained lead, as it caused excessive drossing due to the formation of lead silicate. Copper, such as commutator segments, that had been used for electrical purposes frequently contained silicon, and unless a consignment of this description was known to be free from silicon a trial heat of sand castings should be run of some alloy containing a considerable quantity of lead. If the scrap contained silicon enough to hurt, the castings would show inclusions of a whitish powdery dross. Alloys containing much lead would arouse suspicion by reason of their weight, when they could be tested by indentation with a hammer. It was possible to detect smaller percentages by melting an ingot from the stock and drilling it. If the stock was leaded the chips would break and the ingot would drill fairly easily, but if the chips were curly the stock contained no lead. Iron could be removed from brass when the latter was molten. One method was to add copper oxide to the melt. It was also possible to remove aluminium by copper oxide when present in small amount in copper-tin alloys, but in high-zinc brass this was not practicable, as the zinc was removed with the aluminium. When silicon was encountered in scrap copper it might be removed similarly after the copper was melted by adding copper oxide and a little salt to the bath.

Using Turnings and Borings.

Scrap consisting of uniform solid pieces could be used advantageously directly with a certain proportion of new metal. Chips or turnings, if admixed with iron, must go to the magnetic separator several times before the remelt in order to remove particles of iron. The clean chips might be melted down or briquetted and reserved for use, but they could always be used to advantage directly in brass foundry operations. A method in vogue in some foundries was to use chips in every pot of metal melted. A certain amount of chips was placed in the bottom of the pots, probably about one-fifth of the crucible full, and the ingots were placed on top. The chips melted first and washed off the ends of the ingots. The zinc in the chips acted as a deoxidiser, much of it being volatilised and condensing on the surface of the ingots, thus preventing them from being oxidised as they became heated. Where this practice prevailed little difficulty was experienced from porosity of the castings. It was helpful to add about a tablespoonful of salt to each heat, placing it on top of the chips before adding the copper. Smaller scrap should be fabricated into bundles or briquettes before melting, as it was possible in this way to effect saving in time, to reduce the losses in melting, to simplify the transportation of the metal to the furnace, and to facilitate the charging operation.

Melting Furnaces.

Discussing the melting of the metal, Mr. Bamford said it was only during the severely competitive days of the last decade that the furnace had assumed a position of primary importance and had received the amount of attention which it deserved. The ordinary type of natural-draught pit, coke-fired, crucible furnace was still the most generally employed for melting brass and bronze,

but it had been much improved and made more efficient by alterations in design, chiefly in the introduction of new forms of bottom permitting a more satisfactory supply and distribution of the air, which was in some cases preheated. Mr. Bamford showed a slide illustrating a furnace in which the ordinary fire bars were eliminated and the crucible set directly upon a circular cast-iron base and perforated with a number of round holes. The combustion in this furnace, he said, was complete, practically no CO escaping to the stack. He also described a number of other furnaces. With regard to reverberatory furnaces, these, he said, had been in use for several years to a limited extent for heavy brassfounding. The advantage which they had over crucible furnaces consisted chiefly in the facility which they afforded for melting heavy lumps of old metal without having to break them up. It was also convenient in making heavy casts to melt the metal in one furnace, instead of collecting the charges from several crucibles, which might cause delay and possible want of homogeneity. The price of gas almost prohibited the use of gas furnaces for continuous melting. In some foundries, however, where brass and gunmetal were dealt with in small quantities at a time and where a small installation, providing ready facilities for melting the metals quickly under definite, easily-controlled conditions were the desired features, it might be sound economics to use gas melting furnaces. Oil fuel was now largely used for brass-melting furnaces. It was one of the many phases of the present utilisation of oil for heating purposes. It possessed, like gas, the advantage that little consumption of fuel occurred in the preliminary work of heating up and little delay, since the furnace was started by the turning on of the oil and soon attained its necessary temperature. Further, when a heat, whether long or short, was over there was no waste of fuel surplus burning itself out. The temperature also was regular, no stoking was required, no cleaning out of ashes, and no transit of fuel to the furnaces. Moreover, oil had the further advantage that it was usually an economic proposition, since in an open-hearth furnace of 500 lbs. 12 heats could be run in 10 hours with a fuel consumption of 1.5 gals. of fuel oil per 100 lbs. of brass melted; while using a crucible furnace of 200-lb. capacity, 20 heats could be run in the same time with a fuel consumption which need not exceed 2.5 gals. per 100 lbs. metal melted. A factor which detracted from the use of oil-fuel furnace was that an installation, although not an expensive one, was necessary for the storage and distribution of the oil. Electric furnaces were almost exclusively used in Germany for brass melting.

DISCUSSION.

The PRESIDENT (Mr. D. H. Wood) said Mr. Bamford had dealt with his subject in a peculiarly interesting and valuable way. The Paper had been a most instructive one to both ironfounders and brassfounders.

MR. F. J. COOK (Past President) said they were grateful for hearing a lecture from an able man who had observed details of special interest to foundrymen. It was useful to have had placed before them not only the facts of sound practice but of bad practice also. He considered that the details adduced were so valuable that when the Paper was printed it would form a basis for reference for the producers of non-ferrous castings. Mr. Bamford had dealt with various matters from a broad point of view, and many of his facts were not so well known as they should be. While Mr. Bamford's references to electric furnaces were most interesting, the reason such furnaces were not to any large extent in use in this country was the high cost of electricity. Both in America and Italy industrialists had a tremendous advantage in being able to obtain cheap current, which was so largely available owing to plentiful supply of water power. Regarding the early use of bronze and iron, Mr. Cook pointed out that iron rusted, and when in contact with vegetable matter very soon disappeared. In the British Museum there was a relic recognised as the oldest piece of worked bronze, but he had himself seen in the same room an iron implement which was admitted to be of an earlier age than the bronze relic. As to phosphor bronze, about which the question of 0.5 phosphorus had been introduced, this metal was now being used in fairly large quantities, particularly in the form of chilled sections in connection with turning bushes for automobile engines. It was proving a most suitable material, but 0.5 was rather low, and he thought it was more correct to say that the proportion of phosphorus was anything from 0.7 to 1.0 per cent. In the case of cast iron, from 0.7 to 1.0 per cent. had a tendency to produce blow holes. In regard to oil furnaces there was always the possibility of danger arising from a high percentage of sulphur in the oil, which, of course, was detrimental.

MR. F. C. EDWARDS agreed that the number and variety of alloys were excessive. The practice nowadays was to standardise so far as possible, and he was glad to say this movement was extending. By standardisation they were able to produce more economically, hence its general adoption. However, it was a fact that alloys were increasing in number, and it might safely be said that many more would come along. Referring to the general use of electric furnaces in Germany, Mr. Edwards mentioned that he saw some German castings a short time ago which did not favourably compare with similar castings produced in this country, although he presumed the German castings were the product of an electric furnace. He contended that bronze castings could be made as sound and as good in Great Britain as in any part of the world. The question of contraction in bronze was highly important, especially to those who were required to make patterns to fine limits. Another point which caused considerable anxiety to the pattern-maker was how to arrive at a decision as to exactly how much should be allowed for contraction, particularly when dealing with non-ferrous castings. Especially in the case of castings of, say, 2 ft. or 3 ft. in diameter, it did not always pay to make patterns to the contraction rule. Very often patterns made strictly to rule turned out wrongly. One casting would often come out smaller than another, which might easily be accounted for by running some off at a higher temperature than the rest. It was apparent that ferrous and non-ferrous castings had their own physical problems and special conditions. It was equally evident that some of the conditions existing in the casting of non-ferrous metals would furnish valuable assistance to those dealing with ferrous material. One sample which was brought to his notice was affected by the cooling of the metal. A measure of contraction took place which squeezed the impurities together and they were consequently the last to solidify. He had seen copper which had been described as "all over pimples." No doubt this was due to something of the same nature, having its origin in the gases or impurities.

MR. DONSON, recalling his early experiences in the foundry, described some of the old furnaces in use, several of which had features mentioned by Mr. Bamford. Many years ago he himself used crude oil very successfully; this was at a time when oil could be obtained at a very cheap rate.

Author's Reply.

Replying to the discussion following a vote of thanks proposed by Mr. Johnson and seconded by Mr. Edwards, MR. BAMFORD remarked that it was not sufficiently realised that the soundness of the casting was a very simple thing to detect. In the case of chilled castings, they generally found that it was correct at the top. As regards phosphor bronze, it sometimes happened that any unsoundness which developed in the casting was due to the pouring temperature being too high. Owing to the greater strength obtained, there was a tendency to pour phosphor bronze at a high temperature. On the other hand, if they cast at too low a temperature there was a danger of developing porosity. The presence of sulphur in oils was undoubtedly troublesome, probably more serious than in coke. The best way of eliminating this sulphur was to pour at a sufficiently high temperature. He quite agreed that the steps

taken towards the standardisation of brass alloys was not adequate to the needs of the industry. Difficult specifications were being brought out for all kinds of alloys, especially of the non-ferrous types. Steels in this country were definitely standardised, and it was now possible to refer to a certain number when they required a steel for a particular purpose. The same policy should be adopted by such bodies as the Institute of Metals, the Institution of British Foundrymen, and the Iron and Steel Institute, and pressure should be brought to bear by all combined in this matter. He was also very much interested in hearing from Mr. Dobson of the evidently successful use of oil furnaces many years back. Probably copper was the most difficult of metals to cast, and undoubtedly the question of phosphorus and oxidation was of vast importance. He was pleased to hear a remark as to the value of co-operation between the different societies. The matter was referred to at the recent dinner of the Institute of Metals by Dr. Aitchison. Given co-operation, it would, of course, still be necessary for certain societies to devote themselves to their particular problems and to specialise on their own lines. He would like to see more co-operation between the various societies in Birmingham; joint meetings could be quite easily arranged.

The BRANCH-PRESIDENT pointed out that the Institution of British Foundrymen had already taken steps in the direction of co-operation, and said he did not see why such bodies as the Institute of Mechanical Engineers or the Association of Automobile Engineers should not get together, particularly with a view to some general co-operation in regard to the drawing up of specifications.

NEWCASTLE BRANCH (JUNIOR SECTION).

FOUNDRY WORK FROM THE METALLURGICAL STANDPOINT.

Mr. A. Logan (Chief Chemist of Messrs. R. & W. Hawthorn, Leslie & Company, Limited) gave an interesting lecture on foundry work, from the metallurgical point of view, to members of the Newcastle Junior Section, at a meeting held on January 16, Mr. J. E. O. Little presiding.

In his introduction, the lecturer referred to a statement recently made by Mr. J. E. Fletcher, of the British Cast Iron Research Association, viz.:—". . . perhaps at least 70 per cent. of casting defects may be traced to causes associated with the craftsmanship of founding. . . ." To the metallurgist this was very gratifying news indeed, although, seriously, of course, the statement did not infer any slight or attach any blame to the moulder. He (the lecturer) was in total agreement with Mr. Fletcher in his remark, and, incidentally, had a great admiration for the moulder and his work.

As it was the elimination of the odd 30 per cent. or so of faults due to the material with which he (the speaker) was primarily concerned, he thought it would be of interest to consider briefly a few of them.

Faults due to the material could be classified under one or more of the following broad headings:—(1) Unsuitable composition; (2) unsuitable melting conditions; (3) incorrect casting temperature; and (4) presence of excessive amount of gas, etc.

In some cases trouble may be due to two or more of these causes acting together, or one of the previously mentioned causes may interact and cause a further fault.

The classifications are very broad, and cover quite a number of irregularities. For instance, unsuitable composition would include purely incorrect composition as such, as, for example, in the case of cast iron the material might be too hard or too soft, or spongy and porous. These faults would probably be due to too low or too high a silicon content, or an incorrect carbon content and structural distribution. Apart from actual chemical composition, it would also include what might be termed unsuitable "physical composition," as, for instance, the use of too large a proportion of steel scrap in a cupola charge, or the use of an abnormal or irregular pig-iron from a blast furnace; unsuitable mixtures of dissimilar irons, such as high and low phosphorus irons put through the cupola together, for in this connection it might be stated that nothing like perfect mixing takes place in an ordinary cupola without a receiver.

Similarly, with non-ferrous alloys many cases occur where slight differences in chemical composition have important effects on the alloy.

A high sulphur content is often blamed for many troubles whereas, in many cases, the trouble may be due to a low silicon combined with a high total carbon; or, again, in some cases, may be simply the result of bad cupola practice.

The whole question of the relative harmlessness of the sulphur depends upon the manganese present, and it is generally recognised now that the sulphur-manganese balance is a very real thing. Providing that there is a fair excess of manganese present, there should be no trouble with sulphur up to, say, 0.15 per cent.

Passing on to the question of unsuitable melting conditions, the author pointed out that it was simply amazing to go round the different foundries and see all the assortment of shapes, sizes, and widely different dimensions of the cupolas in operation. One is forced to the conclusion that almost any form of stack can be taken and charged with pig-iron and coke, and, if air is blown in through any shape or size of tuyere and under almost any degree of pressure, then molten cast iron will result. To what extent it is superheated, or at what cost it is melted, is another matter. The latitude of cupola conditions which will give molten cast iron capable of being poured into castings, is really remarkable. This latitude on the part of the cast iron may seem to be a great advantage, and no doubt it is the salvation of some foundries, but he (the lecturer) was inclined to think that it was an advantage that could be well done without. It was obvious that for any one size of cupola there was one set of conditions which would give the best and most efficient results, and any cupola of this size which did not conform to these basic conditions may certainly be giving molten cast iron, but at the expense of some quality—either of superheat, or fuel ratio, or power for air supply, or, it may be, even oxidation of the iron itself.

Part of the trouble with the present-day cupolas is the fact that it is not possible, short of replacing them with new ones, to carry out any material alteration of much value, and in these days of trade depression it is very difficult to get new plant.

Unsuitable casting temperature was rarely the cause of trouble with cast iron, but was of primary importance with practically all non-ferrous alloys. Where trouble is experienced with cast iron, it is nearly always due to too low a temperature rather than to too high.

New Companies.

Coventry Welding & Engineering Company, Vicar Lane, Smithford Street, Coventry.—Capital £5,000 in 8,000 ordinary shares of 5s., and 3,000 preference shares of £1 each.

Stainless Metal Casting Company, Howard Street, Wolverhampton.—Capital £1,000 in £1 shares.

Young & Alexander, Limited, 50, Wellington Street, Glasgow.—Capital £5,000 in £1 shares. Iron and steel merchants. Directors: C. B. Young, B. P. Young and J. Watt.

THE AYRSHIRE DOCKYARD COMPANY, LIMITED, have secured an order for two cargo steamers.

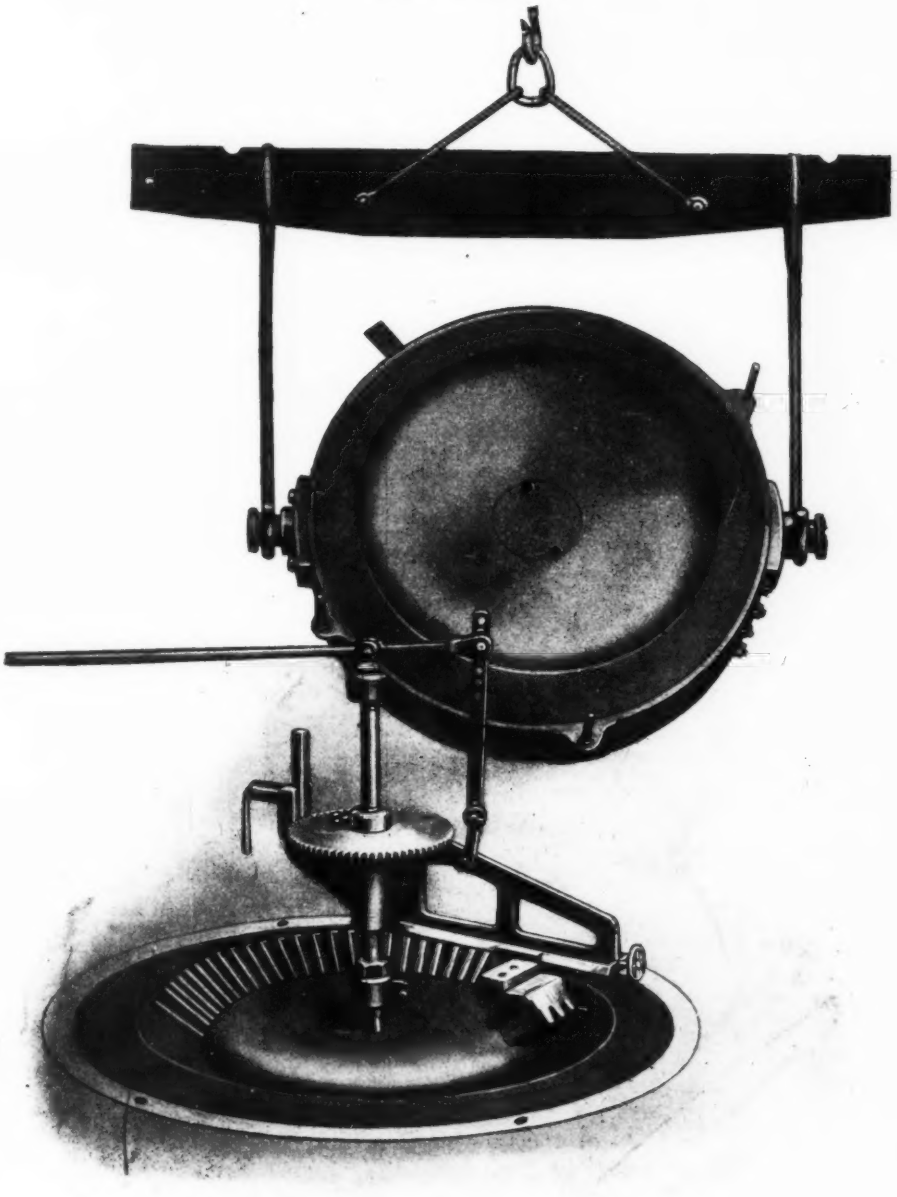
A LECTURE ON MARINE STEAM TURBINES was given, on January 18, at the Department of Applied Science, St. George's Square, Sheffield, by Mr. S. S. Cook, of Wallsend-on-Tyne. Mr. Albert Senior presided.

AT THE JANUARY MEETING of the session of the Staffs. Iron and Steel Institute, held at the Dudley Education Offices, Mr. V. E. Green, of the Research Laboratories, Birmingham, gave an illustrated paper on "Testing of Materials."

THE SUBJECT of "Cores and Core-making" was considered on January 18 at the meeting of the Sheffield Foundry Trade Technical Society, when Mr. G. Edgington read a paper. Mr. J. Emmott presided, and the meeting was concluded by an interesting discussion.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

JAMES EVANS & CO., BRITANNIA WORKS,
(MANCHESTER), LIMITED,
BLACKFRIARS, MANCHESTER.

Trade Talk.

AN AMERICAN ORDER for a 15-ton bell, the second largest ever made in this country, has been given to Gillett & Johnston, of Croydon.

THE BUENOS AYRES AND PACIFIC RAILWAY COMPANY, LIMITED, have just placed a contract with British manufacturers for 44,000 tons of steel rails.

JOHN LEWIS & SONS, Aberdeen, have secured orders for two steamers, the contract prices totalling £43,000 or £44,000. The company are to supply the machinery.

THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, have obtained a twelve months' contract for the supply of Mazda lamps to the Great Southern Railway Company (Ireland).

THE UNITED MACHINE TOOL COMPANY, LIMITED, Holborn Hall, Gray's Inn Road, London, have taken up the British and Colonial selling rights for the chucks made by Paul Forkardt, Düsseldorf.

CARDIFF INTERESTS have purchased the premises originally known as Mordey, Carney's Town Dock Works, Newport, but recently closed down by the Mount Stuart Dry Docks, Limited. These docks will shortly be re-opened.

ENGINEERING TOOLS, LIMITED, 11B, Upper Thames Street, London, E.C.4, are placing on the market a new aluminium solder under the trade name of "Zippo." The hard grade has a breaking strain of 6.35 tons per square inch and the medium grade one of 3.79 tons.

PALMERS SHIPBUILDING & IRON COMPANY, LIMITED, have the order for another vessel for the Gulf Oil Refining Company, Philadelphia, this being the third order from the same firm. It is a vessel of moderate size, and the engines will be supplied by MacColl & Pollock, Limited, Sunderland.

THE ORDERS for heavy rails recently mentioned as having been placed by the home railways have been booked by Steel, Peech & Tozer, Limited, of Rotherham, 4,000 tons; Samuel Fox & Company, Limited, of Stockbridge, 2,000 tons; Cammell, Laird & Company, Limited, Sheffield, 4,000 tons.

THE WOODALL-DUCKHAM COMPANIES are supplying a T.I.C. (lead bath) tar plant, having a capacity of 10 tons of crude tar per 24 hours, to the Urban District Council of Ashton-in-Makerfield. A similar plant, having a capacity of 20 tons of crude tar per 24 hours, is being supplied to the Colchester Gas Company.

MR. P. MITCHELL, Sheffield, has decided to close down the Millhouse Green Wire Works, of which he is the owner. The new portion of the works was destroyed by fire recently, and involved damage to the extent of several thousand pounds. In the circumstances, the business will be transferred to Sheffield, where Mr. Mitchell has a wire drawing mill.

SIR FREDERICK MILLS, president of the Iron and Steel Institute, speaking at the annual dinner of the West of Scotland Iron and Steel Institute, held at Glasgow, referred to the need of safeguarding the iron and steel industry. Sooner than later this country would have to safeguard or—to give it its proper name—protect the great iron and steel industry. There was a curious state of affairs in the country just now. All sorts of luxury trades were flourishing, but the great basic industries, such as iron and steel, coal, shipping, and cotton, were not. The evidence published about the Coal Commission was the sort of stuff which made manufacturers like himself sick. No one wanted men in the coal, steel, and iron trades to work for less wages. What was wanted was longer hours and good honest work by the men employed. America, France, Germany and Sweden were all flourishing under the tariffs. How much longer were we in this country going on without one for the great iron trade?

COMMENTING on the Board of Trade Returns, the British Engineers' Association points out that some of the most satisfactory figures are those relating to the exports of machinery, motor cars, locomotives and electrical apparatus. The total of exports of machinery for December (47,744 tons) is not only the highest monthly total recorded last year, but is higher than that of any month during the past three years. The total exports of machinery for the year 1925 amounted to 515,896 tons—the highest figure for any year since 1913. Without undue optimism, it may therefore be maintained that the steady tendency to improvement recently reported by the Association is generally confirmed by these statistics. It should not be forgotten, however, that the total export tonnage of machinery still represents only 75 per cent. of the pre-war average, and that there is still considerable leeway to be made up, but, given favourable conditions and no acute labour disturbances, it may reasonably be anticipated that the results for the ensuing year will show further and progressive improvement.

THE PRIZE OF a year's subscription to THE FOUNDRY TRADE JOURNAL, offered by the East Midlands Branch of the Institute of British Foundrymen for the best five-minute paper, was won by Mr. H. J. Beck, of Derby.

A FIRE broke out at the Britannia Works of J. Hopkinson & Company, Limited, Birkby. It was found that the fire was burning in the research and experimental department, which occupies a portion of the gallery over the warehouse. The warehouse was flooded, but only a portion of the gallery floor was burnt out. The damage was comparatively small. By a coincidence new buildings are being erected, a considerable portion of which is to be devoted to new laboratories, research and experimental departments, and it is hoped that these will be completed very shortly.

ACCORDING TO REPORTS from Russia, the output of the Tchitaura manganese ore fields, which have been granted as a concession to the Harriman group, is considerably in excess of estimates. The Harriman group has taken over an existing stock of 170,000 tons, and exported the greater part to the United States. From the beginning of operations up to the end of last year about 100,000 tons are stated to have been sold to the Bethlehem Steel Company, and to the U.S. Steel Corporation. It is also stated that these two companies have placed a standing order for 30,000 tons per month. The Harriman interests control the enterprise with a participation of 55 per cent. British interests are represented by a participation of 20 per cent. owned by Baldwins, Limited, Dorman, Long & Company, Limited, and others. The remaining 25 per cent. is held by German and other European groups.

Personal.

MR. G. K. BLYTHE, of Swansea, has been appointed lecturer in engineering to the Glamorgan County Council.

MAJOR A. RHYDDERCH has been appointed foundry manager to Lake & Elliott, Limited, Braintree. Major Rhydderch is a well-known expert in foundry science, and was at one time head of the research department of Hadfields, Limited, Sheffield.

MR. C. AUBREY TATHAM has been elected deputy chairman of the management committee of the London Iron and Steel Exchange. Mr. Tatham is the London manager of the Pearson & Knowles Coal & Iron Company, Limited, the Partington Steel & Iron Company, Limited, and Rylands Bros., Limited.

DR. ROBERT J. ANDERSON, consulting metallurgical engineer, has just been appointed district manager of the F. J. Ryan & Company, industrial heating engineers, of Philadelphia, Pa. Dr. Anderson will represent the company in Cleveland and the Ohio district and surrounding territory. The F. J. Ryan & Company are manufacturers of electric and fuel-fired furnaces, combustion and temperature control systems, oil and gas burners, core and mould ovens, and other industrial heating equipment.

Wills.

BAYLISS, W., of the Woodlands, Newbridge Crescent, Wolverhampton, chairman of Bayliss, Jones and Bayliss, Limited ...	£68,319
BALLANTYNE, R., a director of Stewarts & Lloyds, Limited	£66,496
SPENCE, COLONEL GILBERT O., formerly a director of Richardson, Duck & Company, Limited	£23,360
CLARK, C. E. C., Hathersage, Derbyshire, metallurgist	£8,157

Obituary.

MR. J. THOMAS, of Pontypool, sales manager for many years to Baldwins, Limited, Panteg Steelworks, died recently.

MR. D. A. FIRTH, a director of William Firth, Limited, iron and steel, and machinery merchants, Greek Street Chambers, Leeds, and younger brother of Mr. William Firth, the chairman, died recently. Mr. D. A. Firth was a grandson of Mr. George Firth, who founded the business in 1823. He was 44 years of age, and was well known amongst the collieries in Yorkshire and the Midlands, also on the Leeds, Sheffield and Birmingham Coal and Iron Exchanges.

MR. J. H. PARKER, consulting engineer and merchant, died at the age of 62, at his residence, Oswald Road, Scunthorpe, on January 16. From 1897 to 1907 he was manager of the engineering department at Messrs. Furness & Withy's shipyards at Hartlepool. Later he became chief steel works engineer to the Frodingham Iron & Steel Company, Limited. Ten years later he held a similar position under the Redbourn Hill Iron & Coal Company, Limited. Mr. Parker recently started on his own account as consulting engineer and merchant.

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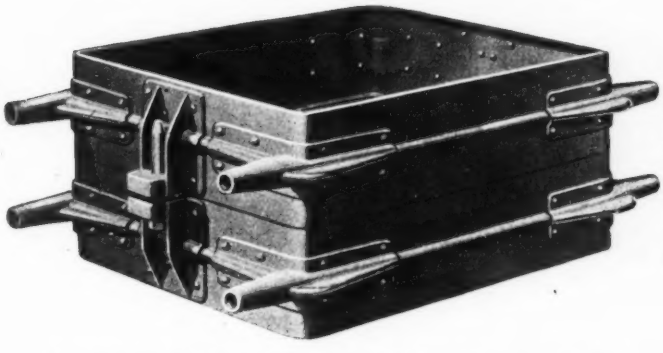

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SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—Increasing activity of demand is again the dominant note in the Cleveland iron trade, so far as home consumers are concerned, furnace outputs at the moment being quite inadequate to the rapidly expanding growth of requirements, while stocks in makers' yards are reduced to negligible proportions. The question of an early expansion of production on Tees-side is understood to be under consideration by iron-masters, but in existing circumstances the high ratio of fuel costs constitutes at the moment an almost insuperable difficulty in an immediate realisation of this pressing need. In the conditions thus outlined, with prompt iron practically at a premium, makers are not troubling greatly about the export position, which remains on the quiet side. Values, meanwhile, show a firm progressive tendency, this week's quotations marking the export f.o.b. price of No. 3 G.M.B. to 70s. 6d. per ton. No. 1 is now 73s., No. 4 foundry 69s. 6d., and No. 4 forge 69s. per ton. Home quotations are 6d. per ton less.

Supplies in the hematite market are now rapidly reaching famine proportions, this quality of iron going into consumption as fast as it can be taken from the furnaces. There is a better demand from abroad, and exporters are experiencing great difficulty in completing cargoes. The home demand is as active as ever. This week 77s. 6d. could still be done, but some sellers were demanding more, and as high as 78s. per ton, a fair average being about 77s. 6d. The No. 1 quality remains at a premium of 6d. per ton. On the North-West Coast there has been no further change in prices, Bessemer mixed numbers being quoted at £4 2s. 6d. c.i.f. Welsh port, £4 5s. to £4 7s. 6d. delivered at Glasgow, £4 10s. delivered at Sheffield, and £4 12s. 6d. to £4 13s. 6d. per ton delivered at Birmingham.

THE MIDLANDS.—Although demand in this area continues steadily active, there has been no further alteration in the values of No. 3 foundry iron. As reported recently, for the time being prices are exceedingly firm, and it is not the period when concessions can be extracted from the furnaces. There has also been a fair amount of forward buying both by consumers and merchants; the former appear to be anxious to cover for the first quarter of the year, and it may be said that the majority has now bought sufficient for its requirements for that period, unless fresh business develops to a greater extent than is anticipated at this juncture. Ruling quotations are as follow: Derbyshire No. 3 foundry, 67s.; Staffordshire No. 3 foundry, 67s. 6d.; Northants No. 3 foundry, 63s. 6d. to 64s.

SCOTLAND.—Though much quieter than the generality of markets, it is satisfactory to record a rather better inquiry for Scotch foundry pig, without, so far, affecting the price ruling, No. 3 quality being still obtainable at 76s. 6d. per ton at furnaces. With another advance in the price of Middlesbrough, for No. 3, the chances for a better demand for Scotch iron are further improved, and we may expect to see the purchases of Cleveland iron falling off.

Finished Iron.

The improvement in business in this class of material recently notified at the quarterly meeting is well maintained, and there is undoubtedly a better demand for crown iron. Prices are, however, still somewhat fluctuating, varying from £11 5s. for certain Lancashire irons up to £11 7s. 6d. per ton, which is the general figure from works in South Staffordshire. The local makers of nut and bolt iron are experiencing a little better support, although they are anything but busy, and the works are only engaged part time. Nut and bolt iron is quoted at £10 5s. to £10 7s. 6d. per ton, delivered, but there has been a fall in the price of Belgian No. 3 iron, which is again offered at £6 17s. 6d. to £7 per ton for April delivery. There has been very little moving in the way of bolt iron business with the Continent even at these prices. The makers of marked bars still quote £14 per ton, and are now somewhat better engaged than of late, when business fell very flat indeed; as it is, they can do with more specifications, as present order books do not take them very far ahead.

Steel.

At Sheffield, the call for basic billets is moderate, but acid qualities are being rather more freely bought. Generally, however, the volume of business has not so far come up to expectations in any direction. Nevertheless works are, on the whole, better employed than has recently been observed. Basic steel departments' output is on about the level of the last six weeks, but manufacturers of special steel report larger orders. Wire-rod mills are quietly employed. A good deal of semi-finished material formerly rolled here for the lighter trades is now coming from Sweden at low prices. In the tinplate market business is in an unsatisfactory state just now. Buyers generally seem to have made up their minds to buy from hand to mouth as far as possible, forward transactions of any moment the last few weeks being conspicuous by their absence. Prices remain on the basis 19s. 4½d. for I.C. cokes, f.o.b. Bristol Channel ports.

Scrap.

Market indications so far as scrap metal is concerned apparently favour an early revival of interest in foundry material. Corresponding to some extent with the reviving activity of demand for iron and steel in Scotland, it is expected that a buying movement will soon take place, as old contracts are pretty well exhausted and wiped off. It is also understood that more work, particularly for steelmakers, is coming forward, and if this continues for some length of time, it is almost certain that better prices will be paid. At Glasgow machinery cast-iron scrap has tapered off a little, as there is not the same demand now, and the price is around 72s. 6d. to 73s. 6d. per ton, and for ordinary heavy cast-iron scrap to the same specification, 67s. 6d. per ton. Old cast-iron railway chairs still remain around 72s. 6d. to 73s. 6d. per ton. Light cast-iron scrap and firebars are somewhat firmer, and for parcels of any consequence 60s. per ton is being paid. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Movements in the standard copper market at the moment continue somewhat irregular, with values still on the down grade, and speculative interest in dealings confined within narrow compass. Competition for new orders has been generally keen by the selling agencies so far as the export markets are concerned. Both Germany and France have made small purchases for prompt shipment, which adds to the belief that consumers are anything but well provided. Adverse financial conditions in these two countries largely explains the cautious attitude of importers. Current quotations:—*Cash*: Thursday, £58 17s. 6d.; Friday, £58 15s.; Monday, £58 7s. 6d.; Tuesday, £58 10s.; Wednesday, £58 7s. 6d.

Three Months: Thursday, £60; Friday, £59 17s. 6d.; Monday, £59 10s.; Tuesday, £59 12s. 6d.; Wednesday, £59 10s.

Tin.—According to Lewis Lazarus & Sons, the weakness in the London market for tin has been reflected in New York where, though some business took place, the tone was easy and prices depressed. The standard market opened lower and with free selling in the opening session. Later trading, however, showed a good demand for all dates, and the market closed strong with eager buyers. Current quotations:—*Cash*: Thursday, £279 10s.; Friday, £281; Monday, £279 10s.; Tuesday, £277 15s.; Wednesday, £276.

Three Months: Thursday, £275; Friday, £275 10s.; Monday, £274; Tuesday, £273 12s. 6d.; Wednesday, £272 5s.

Spelter.—Delays in shipments owing to heavy floods on the Continent have recently had a disturbing effect on the spelter market, and values have given way. Galvanised, state Henry Bath & Son, in their fortnightly metal report, continue to do a quiet business, but have not yet been much in evidence as buyers for forward requirements. The amount of metal sold on the market has been comparatively small, the turnover for the fortnight amounting to only 4,500 tons. Current quotations:—*Ordinary*: Thursday, £37 17s. 6d.; Friday, £37 10s.; Monday, £37; Tuesday, £37; Wednesday, £36 17s. 6d.

Lead.—In the market for soft foreign pig, the position during the past fortnight has been fairly steady, arrivals having been in fair quantity, with the result that prices have declined slightly, particularly for prompt metal. Current quotations:—*Soft foreign (prompt)*: Thursday, £34 12s. 6d.; Friday, £34 10s.; Monday, £34 5s.; Tuesday, £34 5s.; Wednesday, £34.

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THE PREMIER

CYLINDER PIG IRON

SELECTED, FRACTURED & SUPPLIED TO ANALYSIS.

DENSE GREY FRACTURE

UNRIVALLED FOR CLEANLINESS & FLUIDITY.

EXCELLENT MACHINING QUALITIES.

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STEAM, HYDRAULIC, GAS & OIL ENGINES.
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SPECIAL QUALITY FOR AUTOMOBILE & AERO ENGINES.

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WEEKLY PRICE CURRENT.

COPPER.

	£ s. d.
Standard cash	58 7 6
Three months	59 10 0
Electrolytic	65 0 0
Tough	61 10 0
Best selected	62 10 0
Sheets	90 0 0
India	75 0 0
Wire bars	65 10 0
Do. Feb.	65 0 0
Do. March	65 0 0
Ingot bars	65 0 0
H.C. wire rods	69 5 0
Off. av. cash, Dec. 59	12 0 5/11
Do., 3 mths. Dec. 60	12 10 1/11
Do., Sttlmnt, Dec. 59	11 9 9/11
Do., Electro, Dec. 65	16 8 5/11
Do., B.S., Dec.	64 7 0
Aver. spot price copper, Dec.	59 11 10
Do., wire bars, Dec. 66	0 11
Solid drawn tubes	13d.
Brazed tubes	13d.
Wire	10d.

BRASS.

Solid drawn tubes	12d.
Brazed tubes	13½d.
Rods, drawn	11½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g	10⅝d.
Wire	10½d.
Rolled metal	9⅞d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£ s. d.
Standard cash	276 0 0
Three months	272 5 0
English	274 5 0
Bars	278 10 0
Straits	279 5 0
Australian	278 5 0
Eastern	279 15 0
Banca	280 5 0
Off. aver. cash, Dec. 285	1 0 21/22
Do., 3 mths., Dec. 279	3 8 7/22
Do., Sttlmt. Dec. 285	0 5 6/11
Aver. spot., Dec. 285	0 5½

SPELTER.

	£ s. d.
Ordinary	36 17 6
Remelted	36 0 0
Hard	30 15 0
Electro 99.9	40 5 0
English	37 12 6
India	32 5 0
Zinc dust	45 0 0
Zinc ashes	16 0 0
Off. aver., Dec.	37 17 9 9/22
Aver., spot, Dec.	38 6 6½

LEAD.

	£ s. d.
Soft foreign ppt.	34 0 0
English	35 5 0
Off. average, Dec.	34 11 10 3/4
Average spot, Dec.	34 14 9½

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	46 0 0
Do. V.M. ex whf.	44 10 0
Rods	51 0 0
Boiler plates	44 0 0
Battery plates	44 0 0

ANTIMONY.

	£ s. d.
Special brands, Eng.	99 0 0
Chinese	92 0 0
Crude	62 0 0

QUICKSILVER.

	£ s. d.
Quicksilver	15 2 6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon	
25%	£9 15 0
45/50%	£12 2 6
75%	£21 15 0
Ferro-vanadium—	
35/40%	15/- lb. va.
Ferro-molybdenum—	
70/75% c. free	6/- lb.
Ferro-titanium—	
23/25% carbonless	1/- lb.
Ferro-phosphorus, 20/25%,	£19 0 0
Ferro-tungsten—	
80/85%, c.fr. 1/10 lb. to 1/10½	
Tungsten metal powder—	
98/99%	2/1 lb.
Ferro-chrome—	
2/4% car.	£34 5 0
4/6% car.	£23 0 0
6/8% car.	£22 10 0
8/10% car.	£22 0 0
Ferro-chrome—	
Max. 2% car.	£40 10 0
Max. 1% car.	£47 10 0
Max. 0.70% car.	£56 10 0
70%, carbonless	1/5 lb.
Nickel—99%, cubes or pellets	£172 to £175
Cobalt metal—98/99%	10/- lb.
Aluminium 98/99%	£123
Metallic Chromium—	
96/98%	3/9 lb.
Ferro-manganese (net)—	
76/80%, loose	£15 7 6
76/80%, packed	£16 7 6
76/80%, export	£15 5 0
Metallic manganese—	
94/96%, carbonless	2/- lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s. d.
Finished bars, 14% tungsten	2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼in. to 1/16 in.	1/- lb.
Flats, ½in. × ¼in. to under 1 in. × ⅜ in.	3d. lb.
Do. under ½in. × ¼in.	1/- lb
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/s steel makers' work

SCRAP.

South Wales—	£ s. d.	£ s. d.
Hvy. steel	3 7 6	3 10 0
Bundled steel & shrngs.	3 2 6 to 3	6 0
Mixed iron & steel	3	2 6
Heavy cast iron	3 2 6 to 3	5 0

Good machinery for foundries 3 7 6 to 3 10 0

Cleveland—	
Heavy steel	3 2 6 to 3 5 0
Steel turnings	2 5 0
Cast iron borings	2 3 6
Heavy forge	4 5 0
Bushelled scrap	3 10 0
Cast-iron scrap	3 4 0
Lancashire—	
Cast-iron scrap	3 12 6
Heavy wrought	3 7 6
Steel turnings	2 0 0

London — Merchants' buying prices delivered yard.

Copper (clean)	51 0 0
Brass (clean)	40 0 0
Lead (less usual draft)	31 0 0
Tea lead	27 0 0
Zinc	25 0 0
New aluminium cuttings	88 0 0
Braziery copper	46 0 0
Gunmetal	46 0 0
Hollow pewter	185 0 0
Shaped black pewter	143 0 0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1	72/6
Foundry No. 3	70/-
Foundry No. 4	69/-
Forge No. 4	68/6
Hematite No. 1	78/-
Hematite M/Nos.	77/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/3
,, d/d Birm.	93/-
Midlands—	
Staffs common*	—
,, No. 4 forge	60/-
,, No. 3 foundry	67/6
Shrops. basic	70/-
,, Cold blast, ord.*	185/-
,, ,, roll iron*	190/-
* d/d Birmingham.	
Northants forge	55/6
,, fdry No. 3	63/9
Derbyshire forge	60/-
,, fdry. No. 3	67/-
,, basic	65/-
Scotland—	
Foundry No. 1	81/6
,, No. 3	76/6
Hem. M/Nos.	76/6
Sheffield (d/d district)—	
Derby forge	64/-
,, fdry. No. 3	71/-
Lincs. forge	67/-
,, fdry. No. 3	69/-
E.C. hematite	88/-
W.C. hematite	90/-
Lincs. (at furnaces)—	
Forge No. 4	61/-
Foundry No. 3	63/-
Basic	62/-
Lancashire (d/d eq. Man.)—	
Derby forge	68/-
,, fdry. No. 2	74/6
Northants foundry No. 3	76/6
Dalzell, No. 3	110/-
Summerlee, No. 3	94/-
Glengarnock, No. 3	94/-
Gartsherrie, No. 3	94/-
Monkland No. 3	94/-
Coltness, No. 3	94/-
Shotts, No. 3	94/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	11 5 0 to 12	10 0
Angles	11	10 0
Tees to 3 united ins.	12	0 0
Nut and bolt	10	15 0
Hoops	14 0 0 to 15	0 0
Marked bars (Staffs.) f.o.t.	14	0 0
Gas strip	12 10 0 to 12	15 0
Bolts and nuts ⅜ in. × 4 in.	16	15 0
Steel—		
Ship plates	7 7 6 to 7	17 6
Boiler plts.	11	10 0
Chequer plts.	£9 5 to 9	15 0
Angles	£7 0 0 to 7	5 0
Tees	£8 0 0 to 8	5 0
Channels	£ 6 12 6 to 7	2 6
Joists	£7 0 0 to 7	5 0
Rounds and Squares 3 in. to 5½ ins.	8	0 0
Rounds under 3 in. to ⅜ in.	7	15 0
Flats, over 5 in. wide and up	8	10 0
Flats, 5in. to 1½in.	7	10 0
Rails, heavy	8	0 0
Fishplates	12	0 0
Hoops (Staffs.)	10	10 0
Black sheets, 24g.	11	5 0
Galv. cor. sheets, 24g.	16	15 0
Galv. fencing wire 8g. plain	14	0 0
Billets, soft £6 0 0 to 7		5 0
Billets, hard	8	2 6
Sheet bars	6	5 0
Tin bars d/d	6	5 0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3½
Rods	1	3
Tubes	1	8½
Castings	1	2

Delivery 3 cwt. free

10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round— 3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	24.26
No. 2 foundry, Valley	22.26
No. 2 foundry, Birm.	22.00
Basic	21.76
Bessemer	22.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila.	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.50
Sheets, black, No. 28	3.35
Sheets, galv., No. 28	4.60
Sheets, blue an'l'd, 9 & 10	2.50
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	32/6 to 37/6
,, furnace	20/- to 25/-
Durham & North.	
,, foundry	30/- to 33/-
,, furnace	18/-
Other Districts, foundry	30/- to 33/-
,, ,, furnace (basis)	11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes, 20×14, box		19/4½
,,	28×20, ,,	38/9
,,	20×10, ,,	29/-
,,	18¾×14, ,,	20/4½
C.W.	20×14, ,,	17/7½
,,	28×20, ,,	35/6
,,	20×10, ,,	24/7½
,,	18¾×14, ,,	18/6

Terneplates 28×20, 35/9 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£19/0 to £20/0
Rolled Ord.	£16/0/0 to £16/10/0
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12
Pig-iron	£6 15 0 to £7 0 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas	60%	50%
Water	55%	45%
Steam	50%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Jan. 21	58	17	6	inc. 2/6
„ 22	58	15	0	dec. 2/6
„ 25	58	7	6	„ 7/6
„ 26	58	10	0	inc. 2/6
„ 27	58	7	6	dec. 2/6

Electrolytic Copper.

	£	s.	d.	
Jan. 21	65	5	0	inc. 5/-
„ 22	65	5	0	No change
„ 25	65	0	0	dec. 5/-
„ 26	65	0	0	No change
„ 27	65	0	0	„ „

Standard Tin (Cash).

	£	s.	d.	
Jan. 21	279	10	0	inc. 10/-
„ 22	281	0	0	„ 30/-
„ 25	279	10	0	dec. 30/-
„ 26	277	15	0	„ 35/-
„ 27	276	0	0	„ 35/-

Tin (English ingots).

	£	s.	d.	
Jan. 21	278	10	0	inc. 30/-
„ 22	280	0	0	„ 30/-
„ 25	278	5	0	dec. 35/-
„ 26	276	10	0	„ 35/-
„ 27	274	5	0	„ 45/-

Zinc Sheets (English).

	£	s.	d.	
Jan. 21	46	0	0	No change
„ 22	46	0	0	„ „
„ 25	46	0	0	„ „
„ 26	46	0	0	„ „
„ 27	46	0	0	„ „

Spelter (ordinary).

	£	s.	d.	
Jan. 21	37	17	6	inc. 1/3
„ 22	37	10	0	dec. 7/6
„ 25	37	0	0	„ 10/-
„ 26	37	0	0	No change
„ 27	36	17	6	dec. 2/6

Lead (English).

	£	s.	d.	
Jan. 21	35	15	0	No change
„ 22	35	15	0	„ „
„ 25	35	10	0	dec. 5/-
„ 26	35	10	0	No change
„ 27	35	5	0	dec. 5/-

AVERAGE MONTHLY PRICES OF FURNACE COKE, D/D. (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1895	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 3	0 12 6	0 13 3	0 13 3	0 13 3	0 12 5½
1896	0 13 0	0 13 0	0 13 6	0 13 6	0 13 6	0 13 9	0 13 6	0 13 3	0 13 3	0 13 3	0 13 6	0 13 6	0 13 4½
1897	0 13 6	0 13 6	0 13 6	0 13 6	0 13 3	0 13 6	0 13 6	0 13 6	0 13 3	0 13 3	0 13 0	0 13 6	0 13 4½
1898	0 13 6	0 13 6	0 15 0	0 13 6	0 13 9	0 14 0	0 14 3	0 14 3	0 14 6	0 14 9	0 15 0	0 15 6	0 14 3½
1899	0 15 6	0 15 6	0 16 0	0 16 3	1 0 0	1 1 0	1 1 6	1 1 6	1 1 6	1 1 0	1 2 0	1 5 0	0 19 8½
1900	1 5 0	1 5 6	1 6 6	1 8 0	1 8 6	1 9 0	1 9 0	1 8 0	1 8 0	1 7 0	1 3 0	0 19 0	1 6 4½
1901	0 17 6	0 14 0	0 13 0	0 14 0	0 14 6	0 15 0	0 15 3	0 15 3	0 15 9	0 16 6	0 16 9	0 16 9	0 16 4½
1902	0 16 9	0 15 0	0 15 0	0 15 0	0 15 0	0 15 3	0 15 3	0 15 3	0 15 6	0 16 0	0 16 6	0 16 0	0 15 5
1903	0 15 9	0 16 0	0 16 3	0 16 9	0 16 6	0 16 3	0 16 0	0 15 9	0 15 6	0 15 0	0 14 6	0 14 0	0 15 8½
1904	0 13 9	0 13 9	0 13 3	0 14 3	0 14 6	0 14 3	0 14 3	0 14 3	0 14 3	0 14 0	0 14 0	0 14 6	0 14 1½
1905	0 14 9	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 6	0 15 9	0 17 0	0 15 5½
1906	0 17 6	0 17 6	0 17 0	0 17 0	0 17 0	0 16 6	0 17 0	0 17 0	0 18 3	0 18 6	0 19 0	1 0 0	0 17 8½
1907	1 4 6	1 5 0	1 5 0	1 0 6	1 2 0	1 1 0	1 1 0	1 1 0	1 2 0	1 1 6	1 0 0	0 17 0	1 1 8½
1908	0 16 0	0 16 0	0 15 6	0 16 0	0 16 3	0 16 0	0 15 6	0 15 6	0 15 6	0 15 3	0 16 0	0 16 0	0 15 9½
1909	0 16 0	0 15 3	0 15 0	0 14 9	0 15 6	0 15 9	0 15 6	0 15 6	0 16 6	0 17 0	0 17 6	0 17 0	0 15 11½
1910	0 18 4½	0 18 6½	0 18 6	0 18 0	0 17 10½	0 17 0	0 16 1½	0 15 9½	0 15 11	0 16 0	0 15 9½	0 15 8	0 16 11
1911	0 16 0	0 15 10½	0 15 6	0 15 3	0 14 9	0 14 6	0 14 6	0 14 6	0 14 6	0 14 11½	0 15 0½	0 16 3½	0 15 1½
1912	0 17 3	0 17 3	0 18 6	0 18 10	0 19 0	0 19 4½	0 19 10½	1 0 9½	1 2 9	1 4 1½	1 5 8½	1 8 6	1 1 0
1913	1 5 9	1 4 11	1 5 0	1 5 0	1 4 9½	1 0 4½	0 19 5½	0 18 3	0 18 0	0 18 2½	0 18 6	0 18 6	1 1 4½
1914	0 18 2	0 17 1	0 17 0	0 17 0	0 17 4	0 17 6	0 17 6	0 18 5	0 18 4	0 17 9	0 17 6	0 18 5	0 17 8
1915	0 17 10½	0 17 9	1 0 4½	1 7 7½	1 9 4½	1 10 7½	1 9 7	1 7 3	1 5 4	1 4 9	1 9 6	1 13 0	1 6 1
1916	1 10 9	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6½
1917	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 10 6	1 14 3	1 15 6	1 11 2½
1918	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6	1 15 6
1919	1 15 6	1 15 6	1 15 6	1 15 6	2 1 6	2 1 6	2 3 9	2 10 6	2 10 6	2 10 6	2 10 6	2 10 6	2 3 5
1920	2 12 3	2 14 0	2 19 0	2 19 0	3 3 8	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 6 0	3 2 6
1921	3 1 0½	2 19 0	2 16 0	2 7 0	2 6 6	2 6 6	2 0 6	2 0 0	1 13 11	1 12 9	1 10 4½	1 8 3	2 3 6½
1922	1 7 0½	1 8 1½	1 9 7½	1 8 4½	1 7 11½	1 7 3	1 6 9½	1 6 10½	1 7 0½	1 10 2½	1 10 0	1 9 11½	1 8 3½
1923	1 11 3	1 14 6	2 0 1½	2 2 8½	2 4 4½	2 2 10½	2 1 0½	2 1 6	2 0 9½	1 18 9	1 18 8½	1 18 3	1 19 7½
1924	1 16 6½	1 14 9	1 11 11½	1 10 0½	1 8 1½	1 7 8½	1 7 3	1 6 3	1 6 0	1 5 0	1 5 0	1 5 0	1 9 5½
1925	1 4 10½	1 4 1½	1 13 3	1 2 4½	1 2 2½	1 1 5½	1 1 3½	1 4 9	0 18 10½	0 18 4½	0 19 6½	1 1 4½	1 2 8½

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